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PRACTICAL KNOWLEDGE FOR ALL

Volume 1

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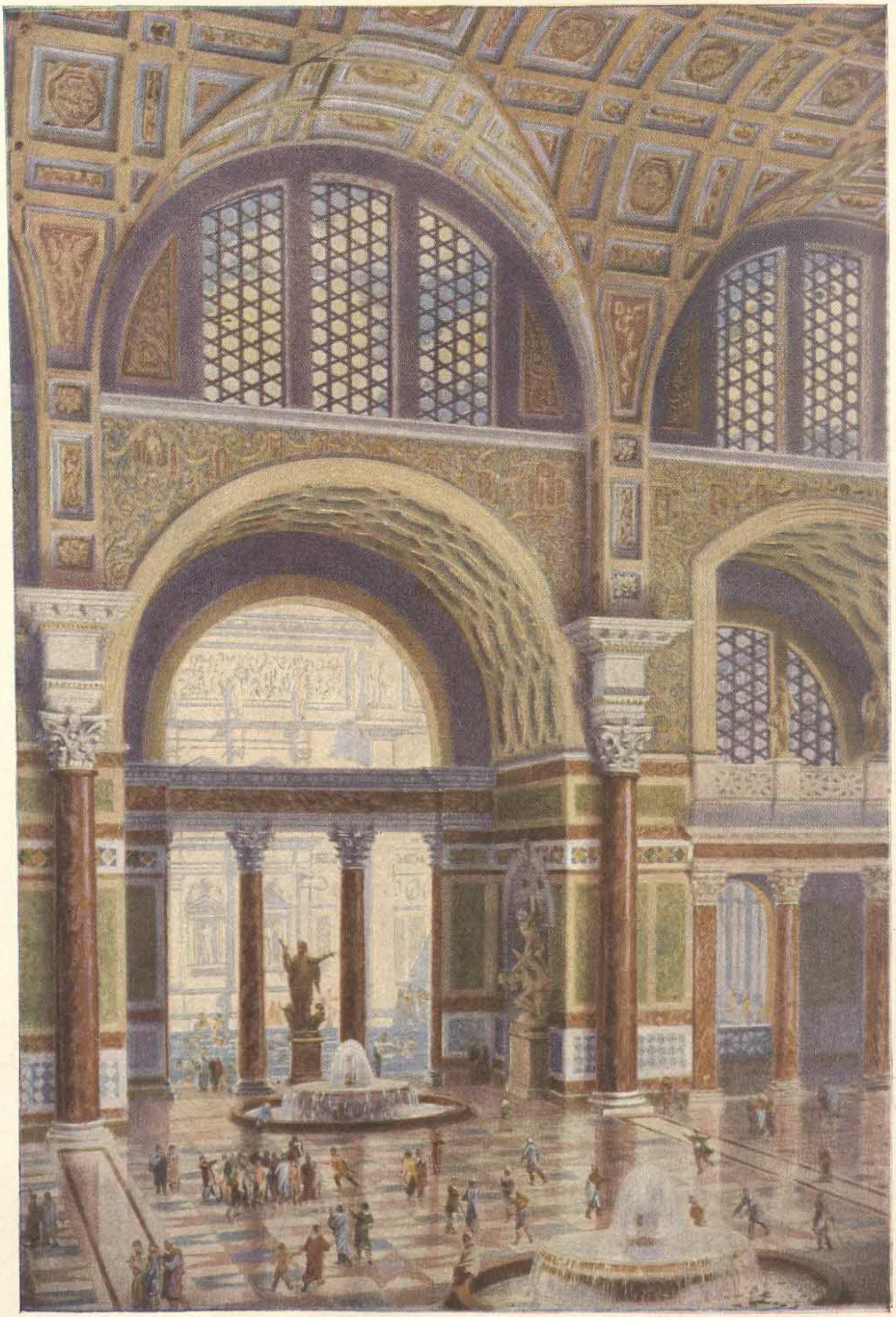

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VOLUME 1

THE WAVERLEY BOOK COMPANY LTD.
London

The Editor's Introduction

These five volumes present a new and completely reconsidered, revised, and reconstituted edition of what has now been established for many years as a standard educational work—by far the most popular compendium of courses in self-instruction ever published in any country.

The many editions of the work published under the editorship of its originator, the late Sir John Hammerton, must have exercised an incalculable effect on the vast body of its readers. Indeed he constantly received from every quarter ample testimony to its solid worth, the most reliable evidence of all being afforded by an ever-growing public demand for the volumes, as edition succeeded edition, with a total sale approaching half a million.

The realm of knowledge is a realm of constant change. Every new discovery, every new step in human history, brings a change in values, a shifting of emphasis in respect of what is of practical importance and what is not. The years since the Second World War have seen the processes of change greatly—even bewilderingly—accelerated. The era of unprecedented scientific achievement upon which this world is now seemingly launched has produced its inevitable effect upon human philosophy. It has brought concurrent, and often revolutionary, changes in man's perception of such things as history, economics, politics, and psychology, and in many other directions.

Inevitably, methods of education have had to change, too ; and methods of *self*-education cannot be allowed to fall out of tune with the times.

For all these reasons, the publishers of Practical Knowledge for All decided that the work must be reshaped, both in its content and in its manner of approach, to meet the needs and demands of a new generation. This has been done, and the volumes are now confidently offered to the public as covering, in a manner at once practical and wholly up-to-date, all that is basic and essential to a liberal education in fifty departments of knowledge.

Each of the fifty Courses of Instruction is, as before, arranged in carefully graded and progressive short Lessons, of the kind that can be grasped by the serious student within half-an-hour or so. Indeed, they have been prepared primarily so that such a reader, one who would look on each half-hour of study as a definite self-imposed task, will derive the fullest benefit from them.

At the same time it is equally obvious that—with the possible exception of the various Language Courses and some of those dealing with technological subjects—the general reader can, if he prefers, follow each Course straight through all its Lessons, perhaps in a couple of evenings, and still derive from it much profit and pleasure. In other words, the general reader has at hand fifty different and distinct treatises, in the perusal of which he cannot fail to find stimulation and the extending of his mental horizon—a library of fifty authoritative books bound up in only five volumes.

The absence of contributors' names is deliberate. They are many, even exceeding in number the fifty Courses, and they are all experts on their subjects, many of them honoured in their particular fields. The stamp of authority will be clear to every reader. But the co-operation of these experts has been so closely interlaced, sometimes as many as three or four working on a single course, that it would be difficult, if not invidious, to specify their individual contributions. Throughout all earlier editions this system of joint authorship was found to lead most surely to a uniform standard of efficiency.

So Practical Knowledge for All is now offered to the public not upon the warranty of such well-known names as might well be mentioned, but upon its already established reputation.

The title of the work has sometimes aroused question. We must point out that the use of the word " practical " was never intended to imply that the instruction given is exclusively technical. Rather is it meant to emphasise the " practical " way in which the instruction is imparted, whether the subject be purely technical or of the more general kind requisite to that culture of the mind which is the mark of a well-educated man or woman. The title may be ambiguous or it may not : but the work has achieved its great reputation under that title, and therefore neither the publishers nor the present editor can see any advantage in changing it now.

Gordon Stowell

Full List of Courses

These are here arranged in alphabetical order according to the volumes in which they appear, so that the combined range of the whole series may be seen at a glance. This order is not necessarily retained within the various volumes, but at the beginning of each volume is printed its own list of Courses, with the corresponding page numbers. A General Index to all text and illustrations is at the end of Volume 5.

VOLUME ONE

Architecture
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Portuguese
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General Index

Editor, Gordon Stowell ; *Chief Associate Editor*, Charles Boff

ARCHITECTURE

Here in brief compass is a comprehensive study of the principles and history of Architecture from Classic Greek to the Modern. Detailed consideration is given to classical and medieval methods and styles and to the developments of the Renaissance. From this point the field is necessarily narrowed to the discussion of architecture in Britain, with a final Lesson on Town Planning.

The reader should refer also to the Course on ART (*Vol.* 3) *and for complementary information on ancient building and housing to those on* ARCHAEOLOGY (*Vol.* 3) *and* SOCIAL HISTORY (*Vol.* 4). *For notes on technical aspects, such as the use of steel and concrete, see* ENGINEERING (*Vol.* 5).

15 LESSONS

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LESSON 1

The Architect and his Work

The modern architect is a trained professional expert employed to design buildings and to supervise their erection. Since the Architects' Registration Act became law in 1931, nobody has been allowed to call himself an architect in England unless his name has been admitted to the Register after his professional qualifications have been found satisfactory. He has to pass certain examinations, normally entailing at least five years of full-time study, and produce evidence of practical experience. He may pursue his studies in a recognized school of architecture ; or he may be articled to a practising architect, and prepare himself for his examinations at evening classes or at home.

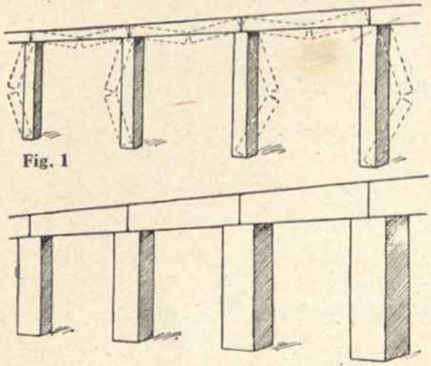


Fig. 1

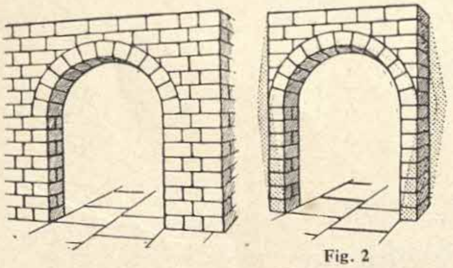


Fig. 2

INFLUENCE OF STRUCTURE. Architecture is influenced by the necessity for a minimum size and strength in the structural units, namely posts and beams (Fig. 1), or arches and vaults (Fig. 2). Weak and strong examples are shown here.

When he has qualified, he is entitled to practise on his own account ; but usually he first enters the service of a practising architect to obtain additional experience, for some years. In recent times the number of architects employed by municipal and other public bodies has increased enormously, and the qualified architect is as likely to obtain work as a public official as he is to create a private practice.

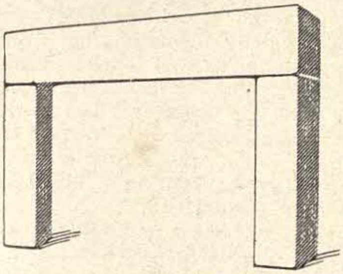
An architect in England must not have any part or interest in a building business. He must be solely concerned to produce a good building in the interests of his employer, the "client." He advises on the choice of a site for building ; prepares sketch-plans embodying the client's wishes and needs ; develops them into finished plans from which a builder can prepare estimates ; draws up a contract between client and builder ; and supervises the building during its erection, from start to finish.

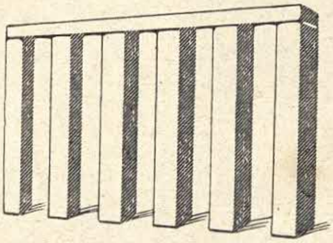
In earlier times the work, status, and training of the architect varied from the modern system. There were Greek and Roman architects long ago ; indeed, the word "architect" (chief craftsman) is Greek in origin. During the Middle Ages (5th century to 15th century A.D.) the term passed out of use almost entirely, and the men who designed the great Gothic cathedrals generally bore the title of "master" in English or *magister* in Latin. They may have been sometimes trained as professional men from the outset, though most of their training took place on an actual building and in the drawing-office attached to it ; or they may have been promoted master-masons who showed special talent. They were certainly laymen, not monks as was once believed ; and if they were working on cathedrals or abbey churches they were hired by the bishop or abbot concerned, to act as expert designers and advisers.

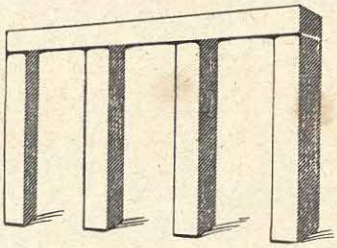
New Type of Architect

With the revival of Roman architecture at the Renaissance in the 16th century (*see* Lesson 9) a need arose for designers who had studied Roman fashions of building, either in Italy or from books ; so a new type of architect emerged, and the old title was revived for him. Inigo Jones (1573–1652) was the first known English architect of this type ; and from his day onwards the status of the architect gradually developed to what it is now.

The English word "architecture" comes from the Latin *architectura*, which is not so old as the Greek word *architektōn* (architect), from which it is derived. It is apparent, therefore, that the architect came first, and that "architecture" meant the sort of building that he produced. In 1624 a diplomat named Sir Henry Wotton wrote a book, *The Elements of Architecture*, from which the following has frequently been quoted : "Well building hath three Conditions : Commodity, Firmness, and Delight." In modern language, good building (i.e. architecture) must be properly planned to meet practical human needs, it must be soundly constructed, and it must give pleasure when one looks at it. So architecture is something more than convenient building or sound building, though it must be convenient and sound: it must make an appeal to the eyes and the senses generally. That appeal can be made by a simple plain building and it is not dependent upon cost, or profusion of ornament. It is a question of quality, not of quantity.







STRUCTURE AND PROPORTION. Above and top right, wasteful use of posts and beams, spacing being either too wide or too narrow. Lower right, economic spacing which produces good proportion.

Because architecture is one of the oldest of human activities, one cannot appreciate it properly without some study of its gradual development through the ages. Such study enables the man-in-the-street, as well as the architect, to form a critical judgement upon any building, old or new; and that is why much of this Course outlines architectural history.

Broadly speaking, building is of two kinds: one using posts and beams, the other arches and vaults; the first involving the use of large members of wood or stone, the other the use of relatively small members of stone as separate units or in the form of concrete. Each system has its limitations governing not only the size and shape of buildings but their architectural appearance.

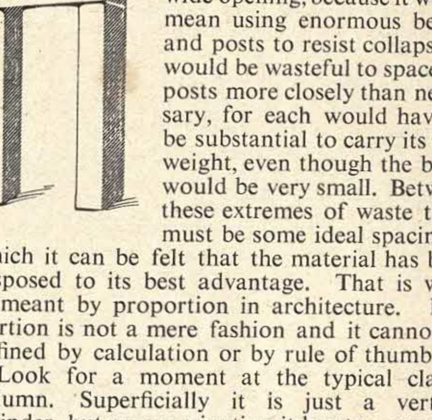
Limitations of Structures

Posts if not sufficiently substantial will buckle and break under a load. Beams will sag and collapse if of insufficient substance. So they must be of a certain minimum size in order to exist in building, and their size creates their appearance—that is, their "architecture."

Vaults and arches, being formed by wedge-shaped small units arranged in a curve across an opening or space, tend to spread at the feet and collapse if sufficient material is not applied in the right place to resist the tendency. So the building of an arch or vault necessitates the placing of a sufficient mass, or "abutment," in the requisite places, in order that the arch or vault may stand. Architecture is created through these simple rules of structure, out of the actual process of building, and not merely out of some vague desire for a particular shape.

There is a natural human reluctance to waste, and when there is adopted a simple system of posts and beams to support a roof over a space the natural instinct is to do that simple task as economically as possible. It would obviously be wasteful to set up widely spaced posts, unless there happened to be a practical advantage in forming a wide opening, because it would mean using enormous beams and posts to resist collapse. It would be wasteful to space the posts more closely than necessary, for each would have to be substantial to carry its own weight, even though the beam would be very small. Between these extremes of waste there must be some ideal spacing at which it can be felt that the material has been disposed to its best advantage. That is what is meant by proportion in architecture. Proportion is not a mere fashion and it cannot be defined by calculation or by rule of thumb.

Look for a moment at the typical classic column. Superficially it is just a vertical cylinder, but on examination it has two peculiar characteristics. The first is that its diameter at the top is less than that at the bottom. The second characteristic is less obvious, but still


Diameter reduced to express relief from columns own weight
curved outline expressing slenderness reinforced
Base expressing the bearing of load including the columns own weight
W
W
W
superfluous material in untapered column
weakness of Column inherent in slenderness

ANATOMY OF CLASSIC COLUMN. These diagrams show how the design of the classic column was conditioned by its main structural use, which is to carry the weight of transverse beams.

FUNCTIONAL BEAUTY. The Pont du Gard, Nîmes, a Roman aqueduct built in the first century B.C., shows how a structure erected for a purely utilitarian purpose, and without elaboration, achieves beauty through its own natural lines.

more valuable in its refining effect. It needs close examination to detect it, but there is no doubt about its deliberate design : the outline of the shaft is not a straight line but a subtle curve swelling from the ends to the middle of the shaft.

When a load is carried upon the top of a column, the foot of the shaft carries not only this weight but that of the shaft itself in addition. If it were a straight cylinder, the bottom of the shaft being adequate for its job, the top would be more than adequate. The eye would subconsciously detect the presence of superfluous material in the upper part of the shaft, unless the designer had had the cunning to forestall this feeling by reducing it in size gradually from bottom to top, as the classic designers did. Thus one of the simplest of building units provides a field for design, so that it may express its own structural nature. Architecture thus concerns not merely the complex building but its simplest elements ; and, in fact, some of the finest buildings are small, and simple in form.

Ornament has its proper place in architecture, but it must not be treated as though it were architecture itself. Applied to building which is itself false and insincere, ornament will not turn it into architecture. On the other hand, a plain but finely conceived structure, unrelieved by any ornament at all, is architecture. Simplicity is, in fact, an architectural virtue.

We have been considering architecture from what is known as a " functional " aspect, which means the direct relation of form to purpose ; and it is true that this logical relationship is a most important one which can never be entirely absent from fine architecture. But that is not to say that unless every element or part of a building can be justified by cold, deliberate reasoning, it should be rejected as inferior.

LESSON 2

Greek Architecture

THE first definite influence upon the architecture of our own times is to be found in the great Hellenic Greek period, about 450 B.C. Greek architecture is based upon the very simple design of the temple, and the fact that a great style could be evolved from such simple elements provides a lesson in architecture. The origin of the Greek temple can be traced from the early buildings of the Greek peninsula. Tombs are frequently found to provide the earliest traces of an architectural style, and this was no exception with the Greeks. The early tomb was regarded as the home of the departed spirit. It took the form of a simple rectangular enclosure, roofed with sloping surfaces to cast off the weather. It is only a step from this to the treatment of a temple as the home of the deity to be honoured ; and the simplest form of temple is similar to the tomb with a porch or portico of columns and beams, which, in the later and more elaborate examples, was carried round the four sides of the rectangular chamber.

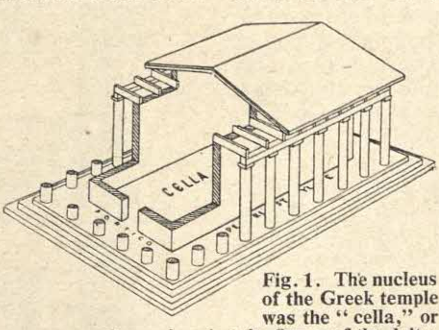


Fig. 1. The nucleus of the Greek temple was the " cella," or enclosure housing the figure of the deity.

The development and refining of the proportions of this simple form of structure cover virtually the whole architectural aim of the Greek period and produced one of the purest styles of all times. It was treated in three distinct forms, all contemporaneous, and representing moods in design rather than periods or place styles, though they are referred to by place names. The Doric, Ionic, and Corinthian Orders, as they were called, were, in fact, Greek architecture in its monumental, graceful, and ornate forms respectively.

The elements of an Order are the elements of post and lintel construction. The first and

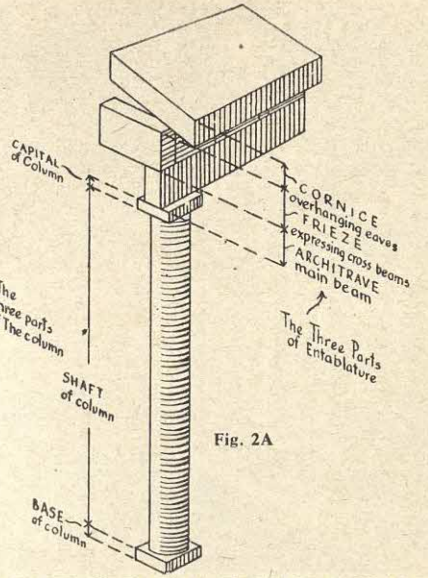

CAPITAL of Column
CORNICE overhanging eaves
FRIEZE expressing cross beams
ARCHITRAVE main beam
The Three Parts of Entablature
The Three Parts of The column
SHAFT of Column
BASE of Column

Fig. 2A

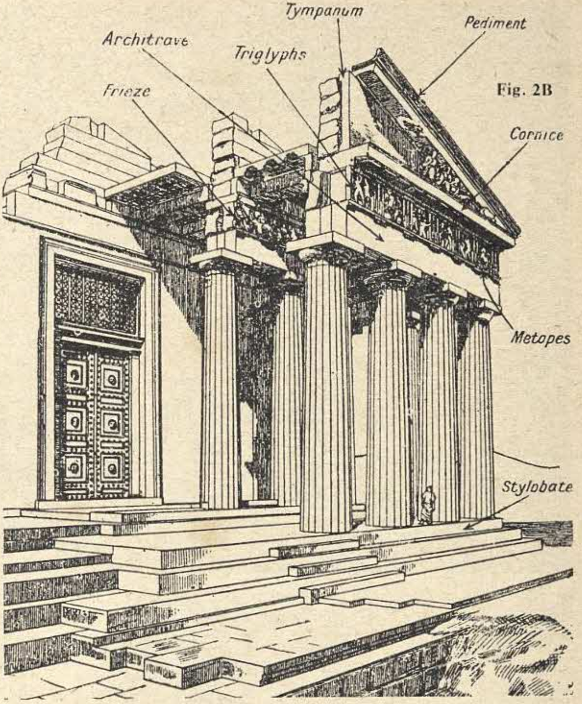


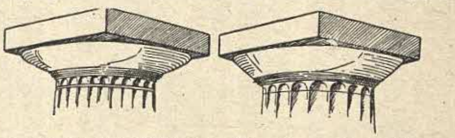
Fig. 2B

STRUCTURAL FEATURES OF A CLASSIC ORDER. The keynote of Greek architecture is the colonnade, interpreted in one or other of the Greek Orders. Fig. 2A explains the terms. Fig. 2B gives a sectional diagram from the Parthenon in which the same parts are assembled. See also illus. p. 6.

obvious element is the post or *column.* The next is the beam running continuously upon the heads of the columns and completing the structure of the colonnade, and called the *architrave.* This beam, in its primitive construction, would be linked with the chamber wall by cross beams, forming a vertical division above the architrave, called the *frieze.* Above these elements would be the overhanging eaves of the roof, known classically as the *cornice.* The three horizontal members together are called the *entablature.* These elements in their relationship one with another are known as a classic Order, and they became an architectural feature associated with fine architecture through many later periods of culture in Europe. Fig. 2B (above) shows the full application of an Order.

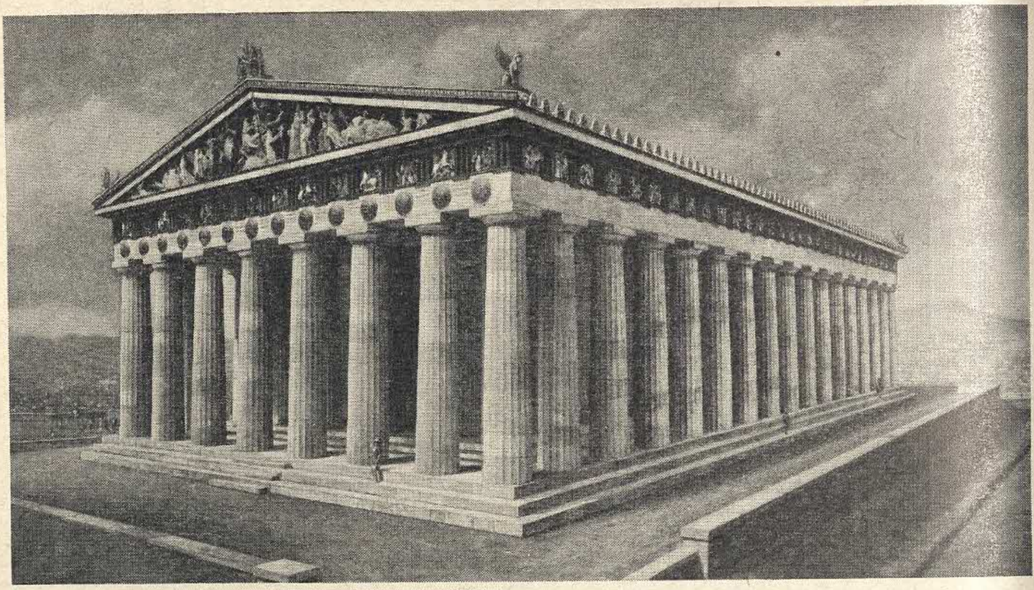
Doric Order

The favourite Order of the Greeks was the Doric, which was substantial and massive in its proportions. It is also particularly expressive of the parts of the structure. The column is plain and sturdy in proportion, the shaft standing direct on a base of three steps forming the platform of the temple, and fluted with hollow grooves meeting at sharp edges and giving emphasis to the lines of the shaft. The architrave is deep and plain, marked only by a narrow band or *fillet* at its meeting with the frieze. The frieze is particularly interesting, in that an alternating pattern of grooved blocks, called *triglyphs* (Greek, three grooves), and square panels suggests the ends of cross beams from which the frieze division was derived, while little peg-like enrichments under each triglyph suggest the fixing pegs that might have been used to secure the ends of timber beams. The cornice is slight and has the form of an eaves gutter at the top, with enrichments on the underside which suggest the feet of rafters. The capitals of the columns develop the round of the shaft to the square lines of the superstructure by means of a refined curve under a simple square block, or *abacus.*



DORIC CAPITALS. Fig. 3. Left, early type, as in the temple of Poseidon at Paestum; right, mature type of Doric capital, as seen on the Parthenon.

Thus was the structure of posts and beams expressed monumentally in terms of stone, producing a composition of great beauty. One can trace the process of refinement by comparing (Fig. 3) the early Doric capital of the temple of Poseidon at Paestum with the mature perfection at the Parthenon, which, though



GREEK DORIC. The Parthenon—Temple of Athene on the Acropolis, Athens—was built (447–438 B.C.) in the Doric style. This model reconstructs it. The corner (left) shows in clearer detail the simplicity and massive grandeur of its columns, the plain architrave above, and the triglyphs and panels forming the frieze. See also illus. p. 5.

relatively small in size, ranks as one of the great buildings of the world.

The Greek Ionic Order was more slender and graceful, more feminine in character. The column is smaller in the proportion of diameter to height, and is fluted with grooves separated by narrow, flat fillets ; there is a moulded base between the column and the platform or *stylobate*. The capital is enriched with scrolls or *volutes* which form the most distinctive characteristic of the Order. This somewhat strange form of terminal probably originates from timber construction, in which it would be natural to provide a short cross member between the column and the beam, which might be countersunk to take the shaft, rounded at the corners, and so provide a natural field for a scrolled enrichment. The architrave is lightened in effect by moulding and recessed planes, the frieze is plain, and the cornice slight and simply moulded.

Ionic and Corinthian

The Ionic capital being essentially a feature designed for a frontal view, there arose a difficulty in the design of a continuous colonnade, since the corner column would exhibit an end view with the remaining side columns turned to show the front faces, or all the side columns would need to be turned with the end faces outwards. The Greek solution was to design a special capital for the corner columns of such a colonnade, in which the angle volute was bent outwards so that both the front and return faces could display their proper frontal pair of volutes (Fig. 4B). In one example, at Bassae, a capital was used in which the volutes of all four faces of all the columns were treated thus, and Roman and Renaissance architects (Fig. 5) often made use of this form of Ionic capital.

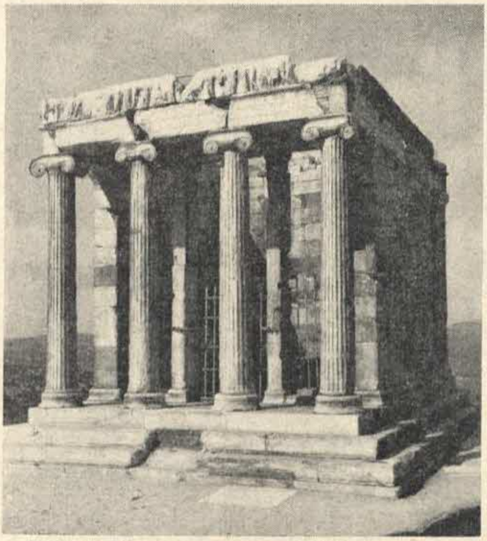
The third of the Orders, the Corinthian, is the most ornate of all, and was the least used by the Greeks. It also is chiefly characterised by the capital of its column, which in other respects is similar to the Ionic. This capital is in the form of an inverted bell supporting a moulded abacus which, on plan, takes the shape of a hollow-sided square. Round the bell are arranged rows of acanthus leaves with the ends turning slightly over and downwards, and groups of volutes support the projecting corners of the abacus. The inverted bell form was a common shape for the capital of a column, and was used in both Egyptian and Assyrian work of great antiquity. The Corinthian capital may have developed from this simple form, to which bronze leaves were fixed by way of enrichment, or natural leaves may have been fixed to such a form on festive occasions. Whatever the origin, the resultant Corinthian capital is a beautiful feature.

The entablature of the Corinthian Order is somewhat similar to the Ionic, but the cornice is further enriched by a row of closely spaced tooth-like blocks called a *dentil course*.

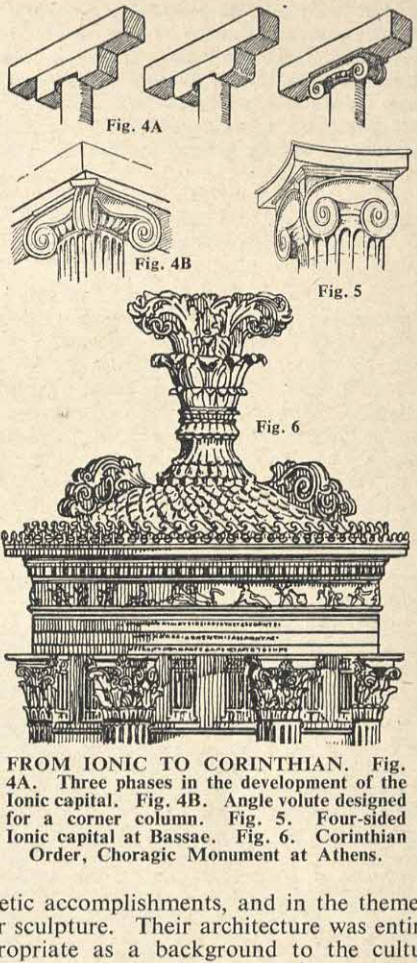
Search for Perfection

The Greek period is famous rather for the quality of its architecture than for the number and size of its buildings. One fine example is the small Choragic Monument of Lysicrates at Athens (Fig 6). This is a circular tower enriched with the Corinthian Order, used to support the tripod trophies which the Greeks awarded in their athletic and cultural competitions.

The whole period was inspired by the Greeks' search after perfection in all things, both physically and spiritually. The cult of physical perfection is evident in their known respect for athletic accomplishments, and in the theme of their sculpture. Their architecture was entirely appropriate as a background to the cultural scheme. A similar harmony of expression is found in the Greek theatre, which took the form of concentric rings of stone seats rising in tiers up the natural or excavated slope of a hill from a central stage with an architectural background. Here the famous Greek drama was performed in inspiring surroundings, and the large seating capacity of the auditorium (that at Epidaurus held at least 16,000) shows that culture was not confined to the few, but was essentially a people's entertainment.



GREEK IONIC. Temple of Nike Apteros, a lovely small building on the Acropolis. It was built of Pentelic marble. The typical scrolled capitals of the Ionic Order are well seen.



FROM IONIC TO CORINTHIAN. Fig. 4A. Three phases in the development of the Ionic capital. Fig. 4B. Angle volute designed for a corner column. Fig. 5. Four-sided Ionic capital at Bassae. Fig. 6. Corinthian Order, Choragic Monument at Athens.

Taste and Proportion

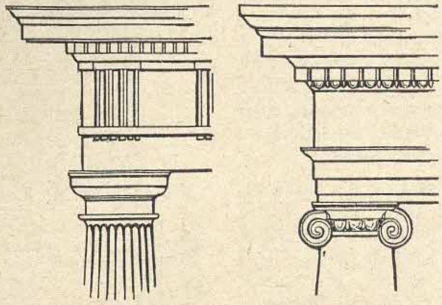
The Greek period thus not only sowed the seed of civilized European architecture, but set a standard of taste and proportion which still exerts an active influence upon architecture.

It should be remembered, however, that the strong sunlight of Greece gave value and effect to subtle refinements of surface and moulding which would be quite lost in the duller light of, say, the climate of Britain. In the 19th century there were several attempts to reproduce Greek architectural treatment, by copying actual examples, arising out of the enthusiasm which more exact studies in Greece itself had created. St. Pancras Church, in London, a replica, except for its spire, of the Greek temple at Athens called the Erechtheion, is one example which succeeds only in appearing very dull architecture, although its model is one of the most beautiful of the Greek examples. At London's Euston Station the great Doric gateway, although grand and dignified in scale, looks inappropriate in the middle of a modern setting.

LESSON 3

Roman Architecture

THE great Roman Empire which spread over southern and north-western Europe, northern Africa, and western Asia, formed the roots of European culture. Roman architecture was founded on local tradition, enriched by the work of conquered peoples, of whom the Greeks provided the richest influences. Before the Roman era there was a skilled race of builders in Italy, known as the Etruscans, famous in particular for their development of the round arch as a bold architectural feature, and having a tradition of temple building on lines not very dissimilar from that of the Greeks. Upon this bold Etruscan tradition the Romans skilfully grafted the beautiful Greek classic Orders, and thus developed the magnificent Roman style which has inspired so much of European architecture since their day.



ROMAN ORDERS. Characteristics of Roman Doric (left) and Roman Ionic (right). Both are from the Theatre of Marcellus, Rome.

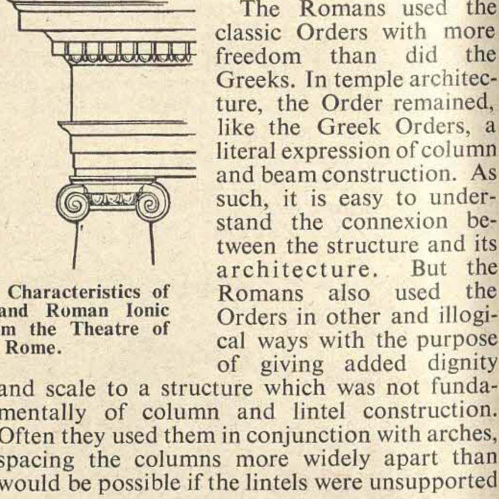
In particular, they evolved Orders following the general characteristics of their Greek models, but translated into terms more suited to Roman taste. The Doric Order, which the Greeks made so imposing and massive as almost to obstruct the practical uses of a building, they converted into a more slender Order, with bolder cornice and mouldings. The Romans were less happy in their treatment of the Ionic Order, though their use of the special type of capital on the Bassae model, referred to and illustrated in page 7, showed a readiness to progress.

Roman Corinthian

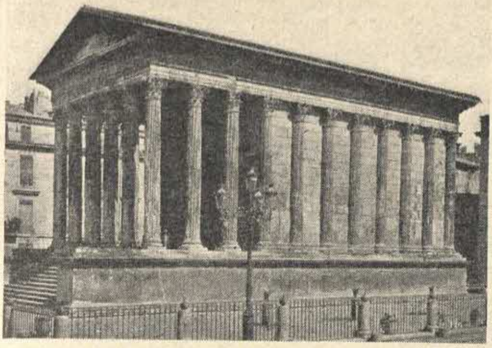
It is in the Corinthian Order that the Romans excelled, and here they produced an ornate composition of great beauty, harmonising with the lavish spirit and scale of their buildings. The Roman Corinthian Order is, in fact, a much more mature feature than its Greek counterpart. The Romans also produced two additional Orders, the Tuscan (a simplified and sturdier Doric), and the Composite (Ionic with a necking of acanthus leaves).

The Roman temple, though outwardly Greek in feeling, was generally more similar to the Etruscan temple in plan and proportion. The chamber was more spacious inside, and less long and narrow than the Greek, and the porticoes were deeper, and approached by bold flights of steps between dwarf walls up to a lofty platform or *podium*. The interiors were also more imposing than the Greek, often being roofed with a vault, and they sometimes terminated in an *apse*.

The Romans used the classic Orders with more freedom than did the Greeks. In temple architecture, the Order remained, like the Greek Orders, a literal expression of column and beam construction. As such, it is easy to understand the connexion between the structure and its architecture. But the Romans also used the Orders in other and illogical ways with the purpose of giving added dignity and scale to a structure which was not fundamentally of column and lintel construction. Often they used them in conjunction with arches, spacing the columns more widely apart than would be possible if the lintels were unsupported



ROMAN CORINTHIAN AND COMPOSITE. Column capital (left) from the temple of Castor and Pollux. Composite style (right) shown in a fragment from Trajan's Forum ; acanthus leaves and other ornaments have been added to the original Ionic.



PERFECT ROMAN TEMPLE. Dating from the beginning of the Christian era, the celebrated "Maison Carrée" at Nîmes is a beautifully proportioned building in the Corinthian style. The temple is 82 ft. long by 40 ft. wide, and was dedicated to the adopted sons of Augustus.

between the columns, and filling in the intervening spaces with arched openings, the arches of which gave the stone lintels intermediate support. The most famous example of this kind of design is the Colosseum at Rome, where the treatment is carried out in three superimposed storeys of Orders, with a fourth plainer storey above.

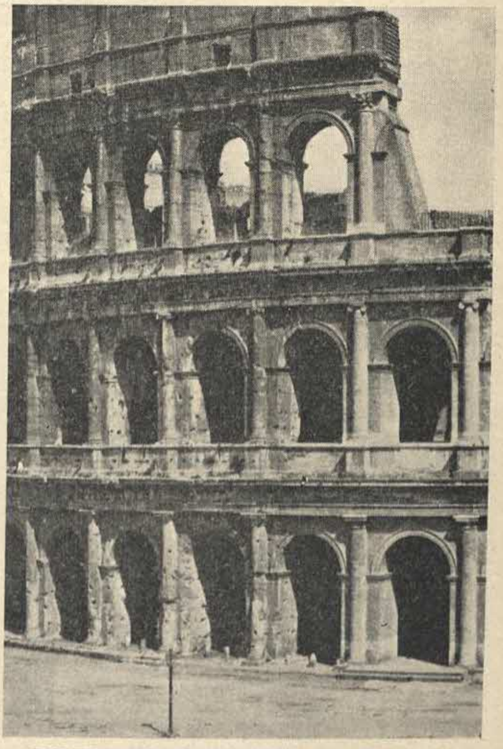
It is a little difficult to justify logically this combination of architecture expressing one kind of construction with building carried out in another, and Roman work of this type has sometimes been adversely criticised as comparing unfavourably with the honest purity of Greek architecture. The outstanding point about such work as the Colosseum is that it does create a fine effect. When one finds the eye and the mind arriving at different conclusions in this way, it is often the eye which proves the truer guide.

The Roman Forum

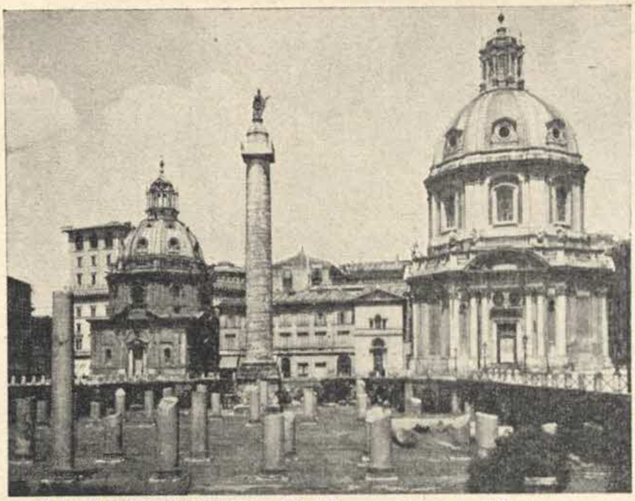
The Romans were skilful planners in the grand manner, placing features of interest at the closing of vistas, and forming grand architectural settings for their principal buildings. The Roman fora were examples of this genius for planning, especially the later examples in Rome, where four of these great spaces, the fora of Trajan, Augustus, Nerva, and Vespasian, were planned side by side. Like the older Forum Romanum, they were civic centres round which were grouped buildings for religious, commercial, and civic purposes, and in them the citizens would meet for all the occasions arising out of their communal life. They were equivalent to the market-place in later country towns, though generally on a larger scale.

The forum was usually rectangular and, on those sides not occupied by buildings, it was surrounded by covered colonnades, often with great semicircular sweeps, or *exedrae*, in or behind them. Some of these were occupied by shops. Trajan's Forum, one of the finest in Rome, is flanked by the great Basilica of Trajan, which was a large columned public hall, at the ends of which were semicircular courts of justice. Behind the Basilica rose the great Trajan's Column, a lofty tower built in the form of a Tuscan column raised on a pedestal, and somewhat similar to the Duke of York's column at the south end of Regent Street in London. The forum does, in fact, typify Roman life and culture, revealing the completeness of the civilized state and its pride and taste in fine architecture.

Another group of buildings which embodies the Roman instinct for finely planned architecture were the great baths or *thermae*, which were the pride of Rome and the Roman Empire. These buildings were centres of social life and relaxation. Large, lofty, and spacious halls were planned in progressive sequence to carry the visiting citizens from one temperature to another, through the various stages of bathing, giving architectural dignity to the setting and affording opportunities for social meetings and recreation. The various rooms were so arranged

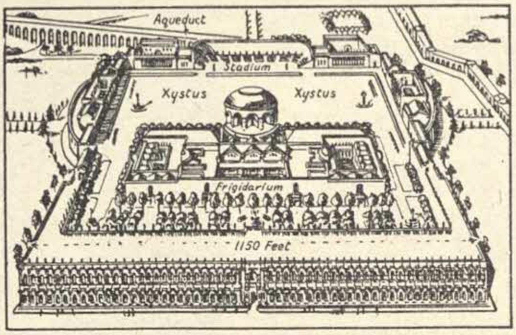


SUPERIMPOSED ORDERS. The Colosseum, Rome, furnishes a famous example of the use of the Orders to give dignity and scale. The storeys are Tuscan-Doric, Ionic and Corinthian.



TRAJAN'S COLUMN. The Tuscan Column of Trajan was set up in an open space near Trajan's Forum. It is 127 ft. high, and is encircled by spiral reliefs forming a continuous narrative of the Dacian wars. His statue on the summit was replaced in the 16th century by one of St. Peter.

that progress from one to another revealed some fine new vista.



BATHS OF CARACALLA. This bird's-eye view gives some idea of the general layout of Roman thermae. The main block covered an area of 270,000 sq. ft. It comprised the three great chambers, round which were courtyards and subsidiary rooms.

From Sir Banister Fletcher, "A History of Architecture" (B. T. Batsford, Ltd.)

One of the finest of these great establishments is that of Caracalla at Rome, which, though in ruins, has provided very full information as to general form and arrangement. The baths were set in a great open space raised upon a platform about 350 yards each way, with a stadium for sports along one side, and lecture halls and libraries on others. The main buildings had as their central feature the great circular calidarium or hot room, separated from the tepidarium, or warm room, by an anteroom, and beyond this was the frigidarium, or cold open-air bath. These were flanked by robing rooms, other smaller chambers probably used for private baths, and columned courtyards, all grouped into one fine scheme of planning.

In England there is a Roman bath in the city of Bath which, altered as it is from its original form, and though on a relatively small scale, gives some idea of the general arrangement of these Roman establishments. It has been restored and put to uses not unlike those of the original building.

ROMAN BATH IN BRITAIN. At Bath the Roman bathing establishment contained several large baths and a number of smaller baths and hypocausts. This photograph shows a circular bath still virtually in its original condition.

The Roman basilica, which later became a model for early Christian churches, was a building used partly as a hall of justice and partly as a meeting-place for business men, like a modern exchange. It had a central space or "nave," with an aisle on either side and separated from the "nave" by a range of columns or arches, above which was a wall pierced by windows giving light to the interior. Sometimes there was an apse at the far end, opposite the entrance.

The Romans enlarged their architectural outlook from the refinement of simple ideas to the enrichment of more ambitious building, and applied their artistic vision to the task in hand, in a true planning sense. But there are other qualities needed to express art in building, and, in a sense, they are the most important of all. These are the ability to build well, and the ability to develop new ways of building. The Romans were supreme in these qualities, which are of such importance that they demand attention in a separate Lesson.

LESSON 4

Roman Building Methods

THE good builder has two main aims : the first is to produce permanent stability, the second is to do this in a tidy and orderly way. The first condition is one without which building cannot for long exist, and it is therefore the most powerful influence upon architectural shape. The second is of more human origin, and comes from deep down in the human make-up. It appears wherever a human being has a job to do, and it makes the doing of the job more pleasant and entertaining than any slipshod work can be. The builder's instinct to work tidily and with order is therefore another powerful influence which has its effect upon the outward form and appearance of buildings.

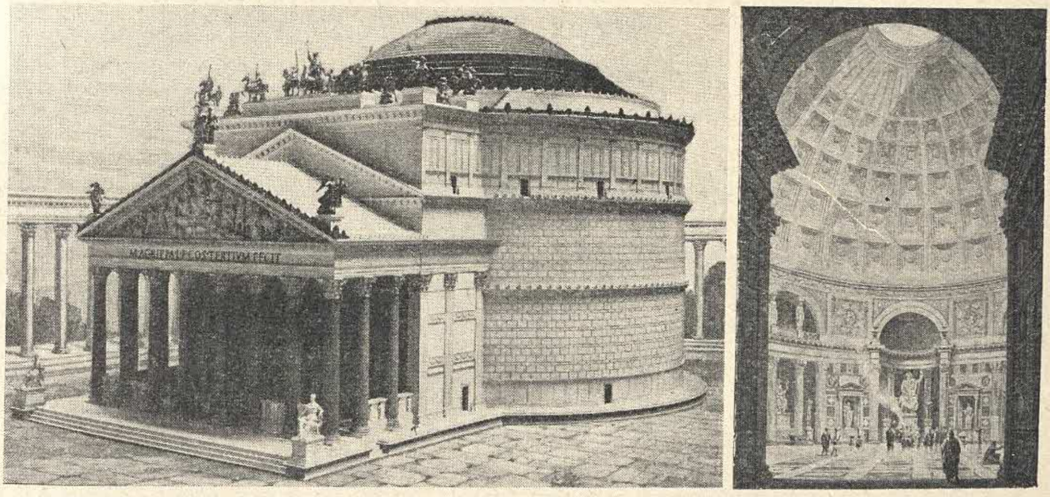
Vaulting and Doming

Most of the great periods of architecture have shown one of the good builder's ambitions to be the covering in of wide spaces with solid fireproof material by vaulting and doming. A *vault* is, in its simplest form, an arch extended longitudinally into the form of a semi-cylinder. A *dome* is arched construction, using wedge-shaped units, but circular in two dimensions, i.e. in a hemispherical form. Both produce fine bold shapes. The Romans were masters in both types of covering. By their skill they brought vaulting to its highest possible development, and influenced the architecture of Europe through every succeeding century. In dome construction they did not develop the possibilities completely, though they provided magnificent examples.

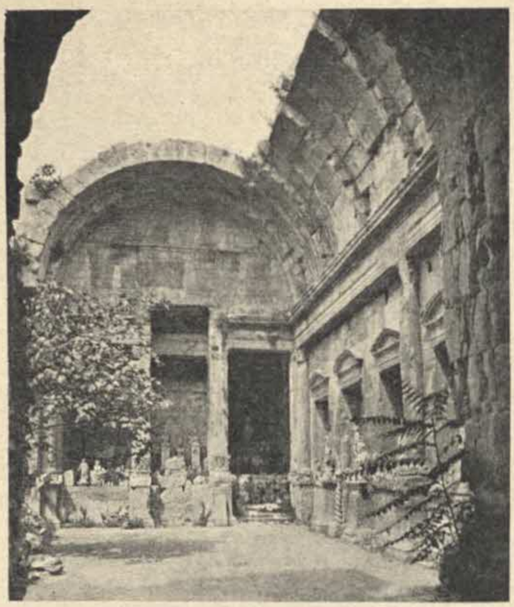
All arched and domed work presents an initial and temporary difficulty during the process of building, in that the structure is unstable until it has reached a certain stage of completion, and it needs temporary support until that stage is reached, that is, until the last stone has been put in its place. With a dome, the stage is reached course by course as soon as each horizontal ring is completed ; so that a dome will stand safely when only partially completed as a hemisphere, as long as the last horizontal ring is complete. The dome can also be built so that it shows less than a complete circle on plan, provided the open ends of the part-circle are made to thrust against a solid abutment. Accordingly the Romans, who frequently used a semicircular apse as a terminal to their buildings, invariably roofed this feature with a half-dome abutting against the end wall of the building.

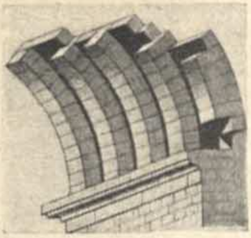
The Pantheon

The greatest and most famous Roman dome is that over the Pantheon at Rome, which still stands solidly more than 1,830 years after it was first built. It is lighted by a great open " eye " 27 feet in diameter, the entire dome having a diameter of over 140 feet. The eye was made possible by the fact that the building of a dome can be arrested at any stage of a completed



GREATEST ROMAN DOME. **The Pantheon, rebuilt by the emperor Hadrian in the 2nd century A.D., consists of a rotunda surmounted by a dome, forming an almost perfect hemisphere 142 ft. in diameter and 140 ft. high. The pillared portico is a survival of the original temple built by Agrippa in 27 B.C. Right, a reconstruction of the interior of the Pantheon, showing the great open " eye " in the dome (see text).**





BARREL VAULT. The Temple of Diana at Nîmes is a stone-vaulted structure buttressed from the inside, the buttresses being disguised as projections between niches. The smaller illustration shows the construction of a ribbed vault.

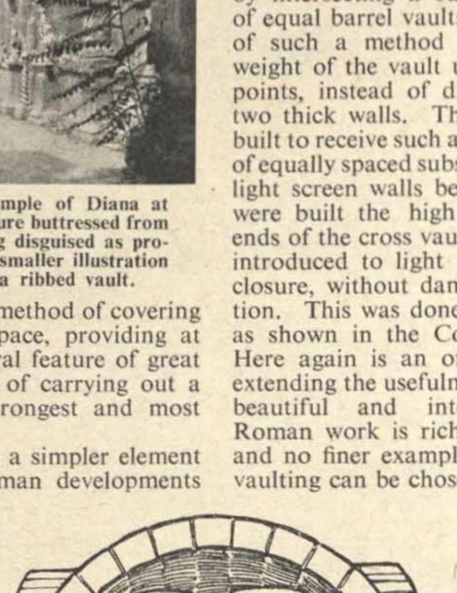
horizontal ring. This noble method of covering a circular or semicircular space, providing at the same time an architectural feature of great beauty, is simply the result of carrying out a piece of building in the strongest and most orderly way possible.

The vault is in some ways a simpler element than the dome, but its Roman developments were more advanced, and they are of great importance in architecture. The simple half-cylinder, termed a *barrel vault*, was known to all arch builders and was used by the Assyrians many centuries before the Roman era. A Roman use of it is seen in the Temple of Diana at Nîmes. It is a natural way of roofing in stone a rectangular space, but its use entails certain precautions essential to ensure stability. The walls carrying such a vault must be continuously thick to resist its natural tendency to spread at the feet and overturn them. Any windows in the upper part of such an enclosure must be in the vertical end walls, since the vault surface cannot be cut into without breaking the arch. So there were these two rather severe limitations to the use of the barrel vault. The Romans overcame them by using the *groined vault*.

If two half-cylinders intersect each other at right angles the cylindrical surfaces meet exactly on the lines of two ellipses crossing diagonally from the opposite corners. In masonry construction the lines of intersection of such a vault are called *groins*.

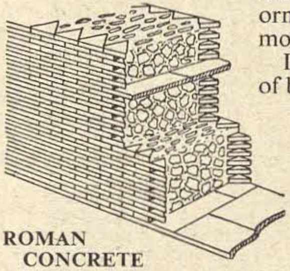
Barrel Vault

A long narrow enclosure was therefore roofed by intersecting a barrel vault with a number of equal barrel vaults at right angles, the result of such a method being to concentrate the weight of the vault upon a number of isolated points, instead of distributing it evenly along two thick walls. Thus the enclosure could be built to receive such a vault by erecting a number of equally spaced substantial piers, with relatively light screen walls between. At the same time were built the high semicircular walls at the ends of the cross vaults, in which windows were introduced to light the upper part of the enclosure, without damage to the arch construction. This was done at the Baths of Caracalla as shown in the Colour Plate facing page 9. Here again is an orderly geometrical way of extending the usefulness of vaulting by forming beautiful and interesting surface shapes. Roman work is rich in examples of groining, and no finer example to illustrate this kind of vaulting can be chosen than the Tepidarium of the Baths of Caracalla, just referred to. The ruins show that the building must almost certainly have been vaulted on the lines indicated in the restored drawing. Here one can see the lightness of the interior arising out of the advantages of groined vaulting, and the beautiful effect these natural forms assume.



GROINED VAULT. Roman builders evolved the groined vault. This drawing shows the concentration of supports, also the improved lighting.

Yet another advance which the Romans made in the process of building arose out of their discovery of a material called Roman cement. The use of lime as a material for cementing was fairly common among builders of more ancient races. Its power of setting depends on its combination with carbon dioxide in the air, the result being a hard material. Because it needs this continuous contact with the air, it tends to set hard only near the outer faces and become a powder in the body of the work where the supply of air has been cut off. Thus common lime has a very limited strength in building, and it tends to thwart any attempt to build on a large scale. The Romans discovered that lime mixed with a natural clay known as pozzolana, ground to a powder, would provide a mortar that would set whether in contact with the air or not, because the combination of materials produced its own supply of carbon dioxide, with the result that the lime formed a hard chalk. This discovery greatly increased the scale and range of Roman building. In actual fact, the material was very similar to modern Portland cement, which is a mixture of lime and river mud.


ROMAN CONCRETE

A still greater advance was the use of concrete with Roman cement as a basis. This was made by mixing broken stone and brick with Roman cement and sand, the combined materials setting into one homogeneous mass of great strength and hardness. Thus walls and vaults and domes could be built by pouring concrete into temporary moulds ; these were removed when the material had set hard, and left a structure which was practically one unit instead of a number of small blocks cemented together. In some cases the Romans built up the outer skins of a thick wall in thin Roman bricks to form a permanent shuttering for the concrete poured between them. The rough concrete and brick surfaces were usually covered with an ornamental facing of stone, marble, or mosaic.

In these essentially practical methods of building one sees perhaps the greatest contribution of the Romans to architecture. But one must not conclude that this great people was purely materialistic, and that architecture consists only in building things which will not fall down. Even a purely utilitarian structure like the Pont du Gard at Nîmes, which was built to carry a water supply across a valley, has all the elements of beauty, based upon the unity of building and architecture (illus. in page 4).

The influence of the Roman tradition in building spread widely, enduring throughout the Middle Ages ; and when, in the 15th century, the people of Europe turned to the classic ruins of Rome for the inspiration of their architecture they were rediscovering the original source from which all their previous work had been derived.

LESSON 5

Early Christian and Byzantine Architecture

THE rise and spread of Christianity has been one of the wonders of history, and under that inspiration some of the finest architecture has arisen. But the Early Christian era contributed less to architecture than might be imagined, for adherents of the new religion were forced to live chiefly underground, and persecution was frequent. At first the converts met in the catacombs for worship and instruction. Then, as tolerance grew in the world above, private meetings in houses took place. In A.D. 313 the Emperor Constantine, having become a Christian, decreed equal rights for Christians, and in 323 Christianity became the established religion of Rome. Thereafter the Christians were free to build, and a great boom in religious building, rivalling the pagan glories of the past, might have been expected. But there was no such rivalry, rather a reaction against the ambitious building efforts of the people who had for so long tyrannised over the new religion.

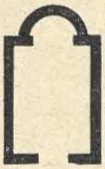
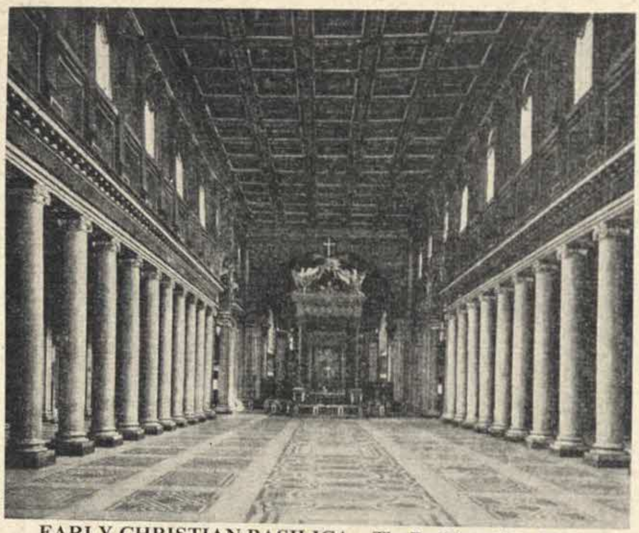


Fig. 1

The chief aim of the Early Christian builder was merely to put a roof over the large congregations which the new freedom made possible. In the year 365 the Roman Empire was divided into Eastern and Western parts, centred at Byzantium and Rome respectively, and in 476 the Western Empire finally fell. Architectural inspiration became divided between two traditions, the Eastern arising out of the bold Roman tradition but modified by more lavish influences from the East, the Western following a simpler course in the western part of the old Empire, but lacking some of its skill.

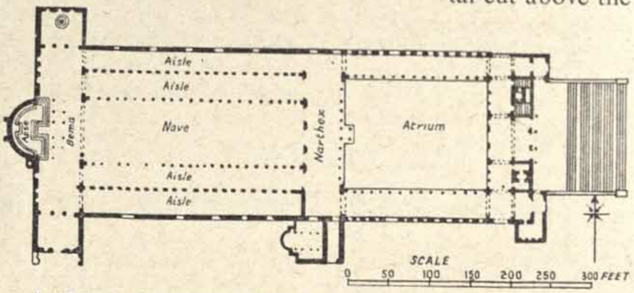
Christian Basilica

The typical building of the Western tradition was the so-called basilican church, a building which has, on plan, some resemblance to the Roman secular basilica, though differing from it in actual interior form. It was probably derived from the room in private houses where early Christian services were held. Called the *schola*, it was a rectangular room, generally with an apse at one end (Fig. 1). This, on a larger scale, was the usual form for the earliest type of church, and as congregations grew in size it was natural to extend such buildings by the



EARLY CHRISTIAN BASILICA. The Basilica of St. Maria Maggiore in Rome is a typical example, and the photograph shows the nave colonnade, blank storey covering the aisle roofs, and the clerestory lighting the nave, corresponding to the nave arcade, triforium, and clerestory of the medieval cathedral.

addition of aisles of lower height, leaving wall space above to provide windows for the main central aisle.



LATER CHRISTIAN BASILICA. The Basilican Church of St. Peter, erected by Constantine A.D. 330, was pulled down in 1506. The atrium, or open forecourt, led through the narthex, an arcaded porch, into the nave, flanked by double aisles. Beyond was the bema, a raised stage reserved for the clergy, and the forerunner of transepts.

As ceremonial developed, extensions near the apse and altar, for priests and choristers, were added to the plan, forming a pair of side wings called the *bema*. With continued development of ritual, the further extension of the apse naturally led to the " chancel ." Thus the Early Church laid down the basic lines of the cruciform aisled plan upon which medieval churches and cathedrals were subsequently to be built. The architectural treatment of this type of building was not ambitious, and in some instances pagan buildings were raided to provide the columns and stones for its construction. The western branch of Early Christian architecture is thus of less interest than other periods, though important in marking a stage at which the traditional form of the Christian church building had been established.

The Eastern tradition, which centred upon Byzantium—a city of many changes, which later became Constantinople and then Istanbul—is of considerable interest. It is famous for one great advance in dome construction, which profoundly influenced the architecture of the Renaissance, many centuries later. The Romans, in their noblest domed architecture, had applied this feature to circular buildings, as the natural way of covering them in a fine way. But the circle is not an easy shape to plan over a square space. The Byzantine builders therefore set themselves to develop a dome over a square compartment, a task which needed the highest qualities of imagination and geometrical skill.

Use of the Pendentive

As has been explained, the dome will remain secure at the level of any completed horizontal ring, and it will stand as a segment of a full hemisphere, provided the interrupted ends are given sufficient abutment. If a hemisphere is cut with five planes, four of which make vertical cuts forming a square on plan, and the fifth a horizontal cut above the crowns of the semicircles formed by the other four, it is found that the hemisphere has been reduced to four roughly triangular segments, the lower points of which stand on a square. By the nature of the dome that shape in solid geometry can be built, and will stand, provided that the vertical interruptions in the dome are supported by an adequate abutment. This may take the form of barrel vaults, or of half domes, or of thick walls. By these means can be built up, in a fine geometrical way, a circular base growing out of a square compartment ; upon which can be erected a hemispherical dome direct, or a cylinder, or " drum," upon which a dome can be raised at a higher level. The name *pendentive* is given to each of the four triangular segments of the sphere formed by the intersection of planes.

This highly developed feature was not a sudden event, for building developments do not arrive that way. The earlier examples in which a dome was erected upon a square compartment were constructed by corbelling out the corners of the square until an octagonal base was formed, upon which a circle could be applied. The pendentive was really a translation

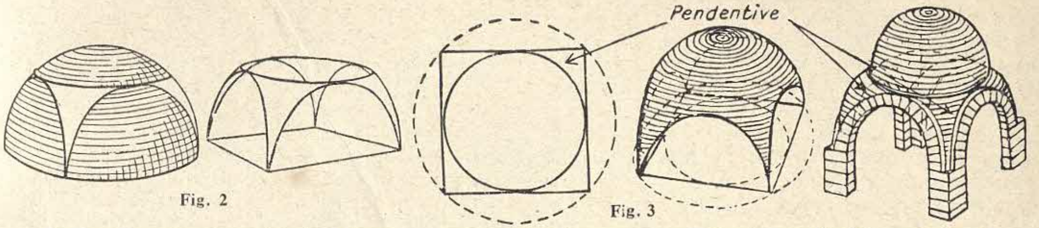


Fig. 2

Fig. 3

USE OF THE PENDENTIVE. Fig. 2. A hemispherical dome may be cut by four vertical planes and one horizontal, so as to leave pendentive segments which develop a square base to a circular foundation for a dome. Fig. 3. Showing the plan and surface of a continuous pendentive dome, and the same type curtailed to carry a separate hemisphere in the fully developed Byzantine manner.

Fig. 3 from Helen Gardner, " Art Through the Ages."

of this form of construction into more perfect geometrical shape, and as such was a major contribution to the progress of building development.

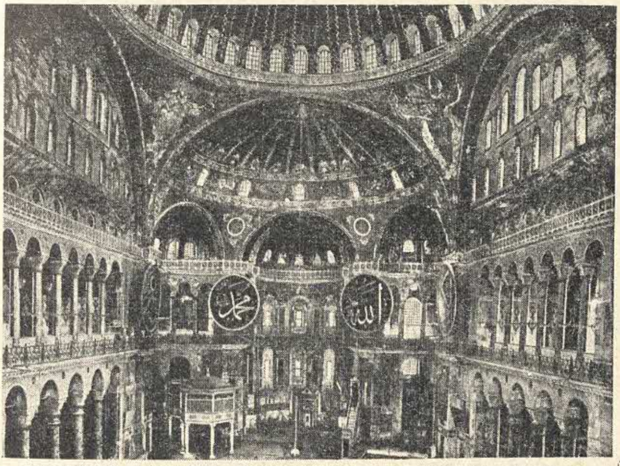
When Roman architecture was revived at the Renaissance (Lesson 9), the new architects used not only Roman methods but this Byzantine advance upon those methods, and some of the greatest buildings of that period owed much of the grandeur of their form to the use of this interesting new feature—the pendentive.

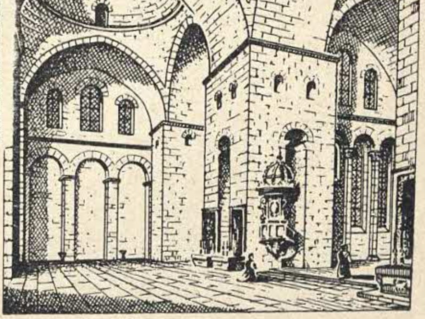
Outstanding Examples

The most famous of the great domed buildings of the Byzantine period is the church of St. Sophia at Byzantium, the plan of which has a great space of 107 feet square, over which a dome has been erected on four pendentives, abutted on two sides by barrel vaults, and on the other two by great semi-domes. The effect of these large elemental surfaces is one of great grandeur, which the lavish Byzantine decoration does not hide.

Although Byzantine influence was centred in Byzantium, and most of its examples are found in the surrounding district, there are also specimens farther afield where Byzantine methods superseded the more primitive treatment of the Early Christian architecture arising from its western centre at Rome. Most notable of these is the church of St. Front at Périgueux, in France. On a very similar plan is the church of St. Mark, Venice. The Roman Catholic Cathedral of Westminster, London, designed by J. F. Bentley (1839–1902), begun in 1895, and consecrated in 1910, follows faithfully the Byzantine tradition.

Byzantine ornament is extremely interesting. Columns and capitals resemble the Roman type, interpreted in a more free and vigorous manner. They were used as supports for arcading in conjunction with a cushion-shaped block of stone called a *dosseret* interposed





FAMOUS DOMED CHURCHES. St. Sophia, built by Justinian at Constantinople in 532–7, is the culminating achievement of Byzantine architecture. The photograph clearly shows the structural features of the dome (pendentives). On the right is the church of St. Front at Périgueux. Built in the Byzantine style, it is cruciform in plan and roofed with five domes on pendentives. Surfaces lack the elaboration of eastern examples.

St. Front from H. Heathcote Statham " A Short Critical History of Architecture " (B. T. Batsford, Ltd.)

between the capital and the arch. The origin of this feature is uncertain, but it may have been a crude representation of the short sections of entablature which the Romans used in similar positions. Possibly dosserets were used to adjust the different heights between odd columns taken from older Roman buildings. More probably they were intended to furnish a wider base for the arches than that provided by the traditional abacus.

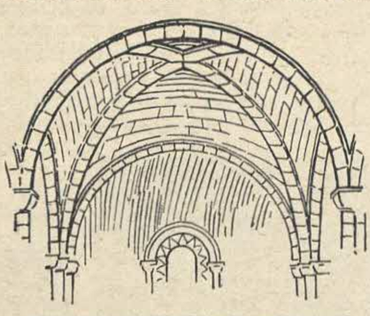
In addition to the Roman types of capital there occurs a more elemental shape called a "cushion" capital, carved with surface enrichment. There is a suggestion of this form in some of the Norman work in Britain. A common Norman variant was the "scalloped" capital.

The Byzantine tradition was remote from Western Europe, and had not the same strength as the Roman tradition, so that this period, apart from its great contribution of the pendentive, had little real influence upon architecture in Britain. It is rather an interlude in the Roman tradition than an important part in the history of the architecture of Western Europe, from which Britain's own national building tradition has sprung.

LESSON 6

Romanesque Architecture

ROMANESQUE means the architecture of Western Europe, including England, from the fall of Rome in the 5th century A.D. up to the beginnings of Gothic architecture at the end of the 12th century; and it is so called because it is based upon the tradition of Roman building, in countries that were once provinces of the Roman Empire. In England it includes the rather primitive architecture, often called "Saxon," of the centuries before the Norman Conquest in 1066; and also the architecture, commonly called "Norman," of the century or so after the Conquest.



Romanesque ribbed vault, made up of round arches thrown across diagonals.

In most of the great periods of building there was a desire to cover buildings in permanent material, such as stone. The domed architecture of the Byzantine builders is an inspiring example. In the West it was not until about the 12th century that this natural outlet for the builder's skill again assumed an important place in architecture. It arose out of the Roman groined vault.

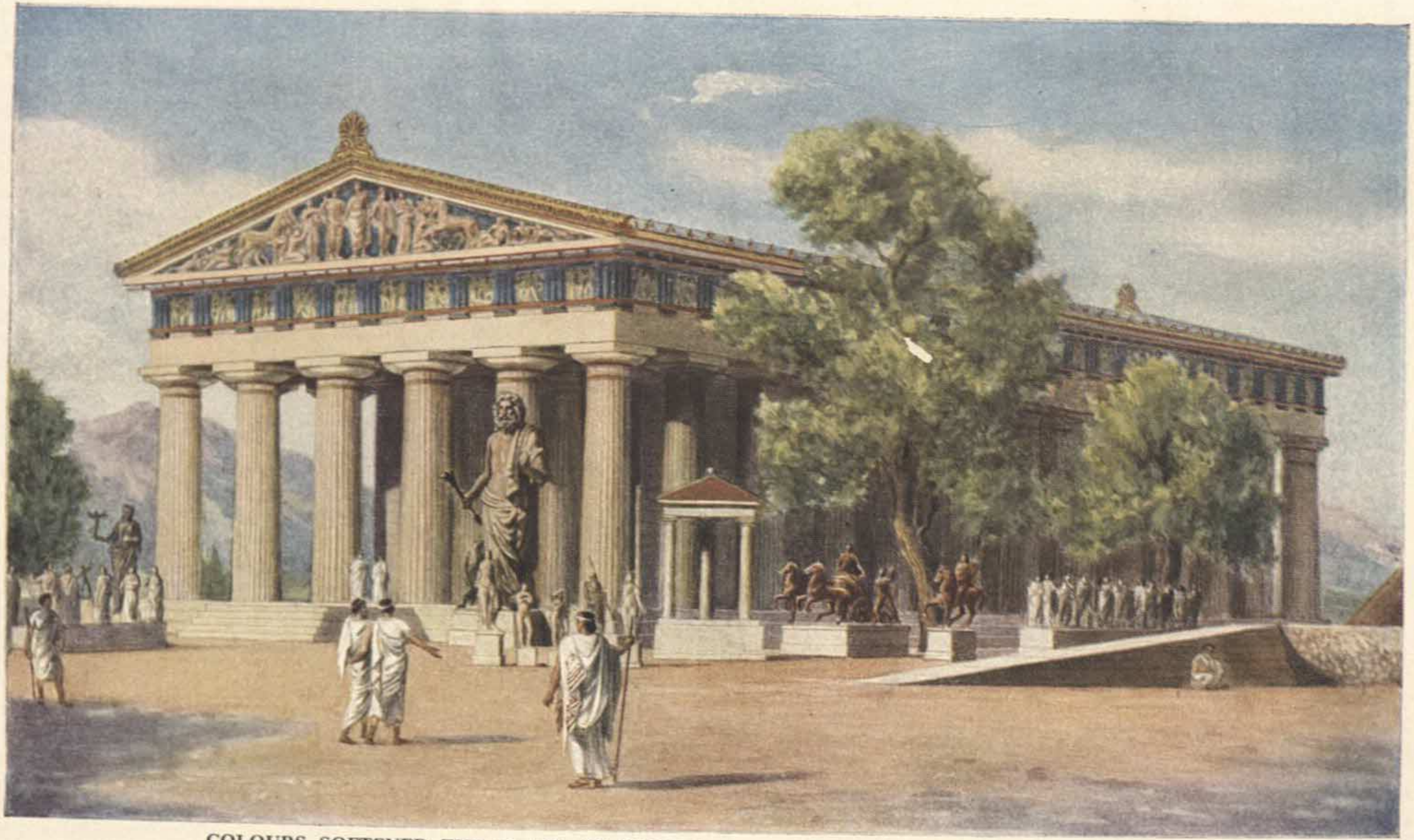
The groined vault, on any scale comparable with a large congregational enclosure, was a great task for any but a wealthy and powerful people to undertake, and the states of the early Middle Ages were certainly neither powerful nor wealthy. So the first influence upon vaulting in the Romanesque period was the need to simplify the task of building and so make possible the greatest effect with the minimum effort.

The first task in the building of a groined vault, or indeed any continuous vault, was to introduce, as a temporary support, a reverse mould of the form it was to take. Such *centering*, as it is called, could be removed only when the whole vault was completed and set hard. This was a major operation, beyond the capacity of those who were poor in labour and material resources. So the simplifying of the centering was desirable, and a reduction of the bulk of material in the vault itself would still further assist.

Ribbed Vaulting

Both these results were achieved by the Romanesque builders by adopting ribbed vaulting. In this system the builders threw substantial stone arches across the open ends and across the diagonals of each vaulting bay, roughly on the line that would be followed by the intersection or groin of a Roman vault. These arches could be erected with very much simplified centering, after which light panels of stone could be arched between them to complete the stone covering. Of the various vaulting ribs, those thrown across the open ends were the transverse ribs, those across the diagonals the diagonal ribs, those over the line of the enclosing walls the wall ribs.

The chief difference between the Roman and the Romanesque vault is that whereas the first intersects geometrically over the diagonals of a square bay, the second has a defined arch thrown across the diagonals, to which the surfaces conform. The Romanesque builders, however, were wedded to the Roman round arch, a fine bold feature but one with limitations. It is traced easily with the compasses, or with a string or rod pivoted at a point, and needs only an elementary knowledge of geometry. But the diagonal groin of the Roman vault was actually an ellipse, a figure of much greater complexity. Romanesque builders were not



COLOURS SOFTENED THE GLARE OF WHITE MARBLE UNDER THE BLAZING SUN OF GREECE

The ancient statuary that now adorns museums, and the weather-beaten ruins of Greek temples that survive, have mostly lost all traces of colouring and thus give the impression that the art of the Greeks was a " white " art. This is far from the truth. The statues were tinted ; those close to the eye in natural shades, those high off the ground, as in temple pediments, in a bolder, more conventional fashion. The temples themselves were picked out in brilliant hues. All this can be realized from the reconstruction above, which so far as the form is concerned is based on the Temple of Zeus at Olympia.

After the reconstruction by Curtius and Adler ; colour details from Leon V. Solon, "Architectural Polychromy"

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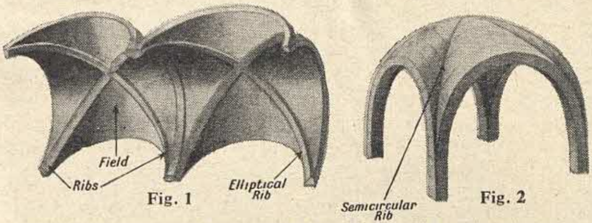
ARCHITECTURE, LESSON 2

prepared for any arch outline less simple than the circle, and the ribbed vault was made up entirely of circular arches, both for the transverse and wall ribs and for the diagonal ribs. The round arch has, however, this limitation, that for a given span there is only one semicircular arch that will fit, the height of which is a fixed value, so long as the arch is a true semicircle. Thus it followed that as the diagonal rib must of necessity be of greater span than the transverse rib, it was bound to rise above it at the crown, and that the light stone filling made to conform with the lines of such ribs would assume a domical form. The Romanesque vaulting bay therefore assumed a shape very far from the regular precision of the original Roman groined vault. In a sequence of bays such as would be used to roof a long narrow nave or aisle the vaulting surface would thus become a series of waves, somewhat restless in appearance.



DEVELOPMENT OF DOMICAL FORM. The ribbed vault (Fig. 1) was arrived at by building the groins first, like girders, and filling in the fields with lighter material. It was then found that if the groins were made semicircular (Fig. 2) instead of elliptical, they rose higher than the bounding arches and a domical form of vault would result.

No. 1 based on a model by Prof. Baldwin Brown.

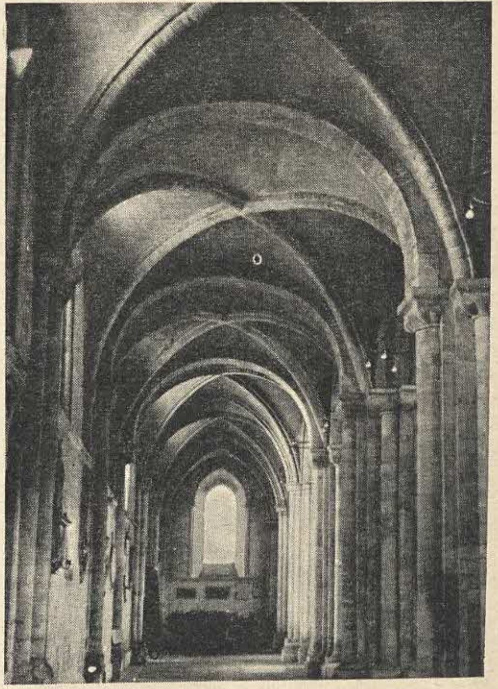
Norman Architecture in England

Very few old cathedrals and parish churches exist that have not some Norman work in their fabric, even though much of it has been so altered by subsequent reconstruction as to be indistinguishable by its outward features. If one looks at vaulted examples, such as Peterborough Cathedral (Northants) or Romsey Abbey (Hants) one can see how the stubborn qualities of the round arch worried the Norman builders, and how they tried to eliminate the difficulties it seemed to force upon them. One sees two main efforts to reduce the natural domical shape of the round arched ribbed vault to a minimum. The first was by making the vaulting bay nearly square, and never long and narrow. There are not many English examples of cathedrals in which the nave has a Norman vault, though there are several examples of Norman vaults in aisles. But where a church was to be vaulted in all three divisions, whether carried out or only planned, it was the Romanesque practice to make two aisle vaulting bays equal to one nave bay, so that alternate piers in the nave arcade would be large, to carry the supports of both nave and aisle vaults, the intermediate piers being smaller, since they had to support only the aisle vault. Not every church which lacks this arrangement of alternate piers need be considered of later date. It is always safe to assume that where a church has this arrangement it is Norman. It is seen at Romsey, although there the nave has not been vaulted, and in this example there is the opportunity of seeing the Norman vault of the aisles partly replaced by later Gothic vaulting, and of comparing the form of one with the other. In spite of sundry defects the Norman vault thus opened the way to Gothic architecture, while in itself never completely satisfying the skilled master masons of the times. Yet it has fine, bold qualities which are very impressive and owe not a little to the the round arch.

The Norman way of building arches for door and window openings is original, and it was continued in principle throughout the early centuries of Gothic which followed.

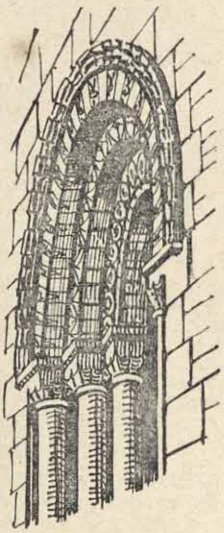
Other Characteristics of Norman Building

Here, again, conditions of building produced a distinctive style. The Norman walls were



ROMSEY ABBEY. One of the aisles at Romsey Abbey, Hants, a fine example of Norman architecture, showing the Romanesque and Gothic vaulting.

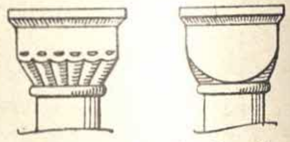
thick and substantial, and an arch carrying the weighty superstructure above and covering the thickness of such walls would have had a deep *soffit*, or underside, requiring a substantial centering like a short vault. The problem was simplified by building the arches in steps, so expanding ring by ring from the bottom, until the full wall was supported. In this way an arch could be built by erecting the first ring upon a narrow centering, and upon this ring the remaining rings could be laid without any further centering. These bold recesses in the line of the round arch, enriched with the primitive but effective Norman ornament, mainly in zigzags or chevrons, are most characteristic.



Doorway at Elton, Yorks, showing the recessed arch.

Windows of "Saxon" churches in England before the Norman Conquest, were small and narrow, sometimes not much more than loopholes. Norman windows were invariably round-headed and of medium width, without any of the tracery used in later Gothic architecture. Though much has been said about vaulting in this chapter, few small parish churches, and not all the larger churches, had vaulted roofs; open roofs of timber were more usual.

Norman piers are notable, especially where they suggest the old Roman capitals from which they were distantly derived. There are types with crude scrolls at the corners, very unlike the Ionic volute, but certainly derived therefrom, and others with crude leafage suggesting a Corinthian prototype. The more usual Norman type was one which resembled very little the classic capital; this is the "cushion" cap. Another variant of the same type is the "scalloped" cap, which is probably the most common of all.



Norman capitals of "scalloped" (left) and "cushion" types.

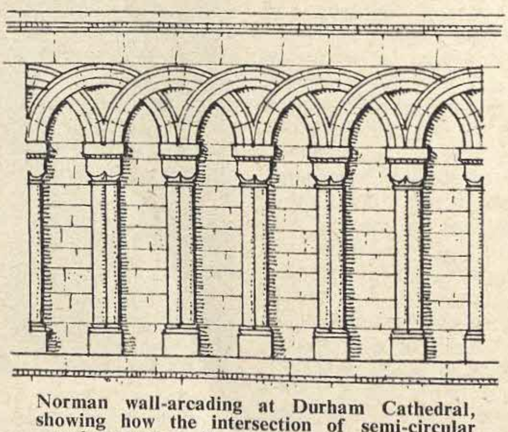
During the Norman period English architecture advanced to such an extent that in little more than a century the primitive Saxon style, with its lack of civilized taste, gave place to the mature Gothic style which was to produce during the next three centuries some of the most glorious architecture of any place or time. Gothic architecture cannot really be understood without first studying the Norman period.

Dwelling-houses and the castles of the nobility are described in Lesson 13.

LESSON 7

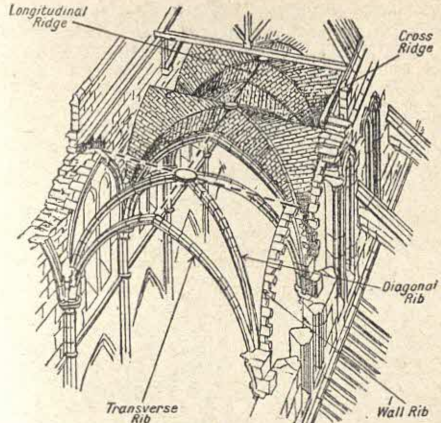
Gothic Architecture

In the preceding Lesson architectural history was left at a very interesting phase. Builders in countries of small population, little wealth, and comparatively primitive resources, had achieved their primary ambition, that of roofing their greater buildings handsomely with stone. The struggle to perfect the form of ribbed vaulting has been noted; also, that the chief difficulties standing in the way of further refinement were caused by the uncompromising nature of the round arch, which, in its perfect form, tied the builder to certain geometrical limitations. The introduction of the pointed arch cleared the way to the overcoming of these difficulties and formed the central fact in the great Gothic movement.



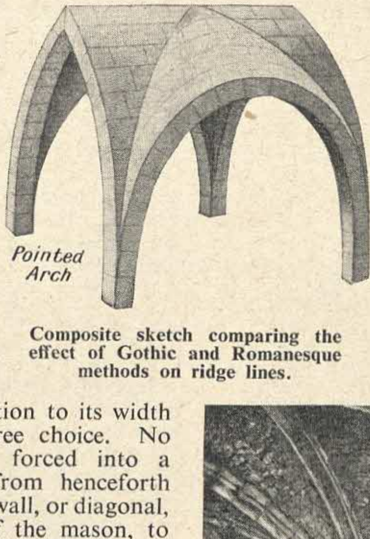
Norman wall-arcading at Durham Cathedral, showing how the intersection of semi-circular arches produces the shape of pointed arches.

It is known that the pointed arch first appeared in the East and was noted, no doubt, as a strange form by the earliest Crusaders. It was probably in this way that the Norman masons learned of the form, and saw its possibilities. Its origin has also been attributed to a Romanesque decorative feature with which the Norman builders were familiar. This was miniature surface arcading, in which little round arches interlaced in a continuous pattern, frequently seen on buildings of this period. In the pattern are formed, merely by the accidental inter-



GOTHIC VAULTING. Diagram showing how the Gothic vault was used. Stone vaulting over churches was protected from the weather by timber roofs covered with tiles, slates, or lead.
After Jackson, " Gothic Architecture."

section of semicircles, pointed arches of varying proportions.



Composite sketch comparing the effect of Gothic and Romanesque methods on ridge lines.

The whole difficulty with the round arch was that there was no satisfactory compromise in the relationship between height and width, and it seems probable that some master-mason, deeply concerned in his problem of eliminating the disabilities of the round arch, may have seen in this pattern, almost in a flash, the complete solution of his difficulties. He would perceive that once the pointed form was accepted, the height of the arch in relation to its width would become a matter of free choice. No longer would the vault be forced into a steeply domical form ; for from henceforth all the ribs, whether transverse, wall, or diagonal, could be made, at the will of the mason, to rise to a common height, while still springing with perfectly natural curves from the same springing point.

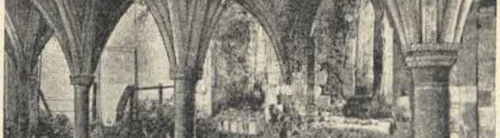
It may not have happened in this way, but the effect of the discovery was as described, and the architecture of the countries in which the pointed arch gained firm hold took on a new lease of life, initiating the glories of the Gothic period. One finds, in fact, in the transition period between Norman and Gothic, that the pointed form was used in work otherwise typically Norman, purely as a shape that had become the fashion. Generally in such cases the point was very slight, and unrelated to any vaulting problem. But there is no doubt that it was the freedom it gave to the vaulting problem that made it the main feature in Gothic art. In the early Gothic period full advantage of this feature was not taken to make the vault ribs all of one height ; but, as the style matured, the tendency was to develop the vault with a main ridge actually level with, and expressive of, the long rhythm of a nave or aisle.

Features of Early Gothic

In vaulted churches, the wall-ribs created pointed spaces in aisle and clerestory walls, and the windows naturally conformed to such an outline. It was natural for doorways to conform to the same shape, and for pinnacles, spires, and finials to point sharply to the sky and so complete the restless, vital character of Gothic architecture, which, opening with the 13th century, developed and persisted for some three hundred years. Gothic in England assumed many distinctively national features.

The successive stages of English Gothic architecture are usually described as Early English or Early Pointed, *c.* 1190–1300 ; Decorated or Middle Pointed, *c.* 1300–1360 ; and Perpendicular or Rectilinear or Late Pointed, *c.* 1360–1540 ; but between the stages there were transitional periods, change taking place very gradually.

The Early English vault of the 13th century was a fine simple feature, known as the *quadripartite* vault, from the four parts into which the vaulting bay was divided by the diagonal ribs. It was pointed vaulting in its



QUADRIPARTITE VAULT. The crypt at Waverley Abbey, Farnham, affords a good example of the Early English vault, developed in the 13th century. The photograph shows each vaulting bay divided into four parts by the diagonal ribs.

purest form, and the Gothic style was never more alive and purposeful than in the 13th century. In the next century the tendency was merely to beautify an already developed feature, and the introduction of intermediate ribs between the main ribs of the quadripartite vault was the main characteristic of the 14th century. These ribs did little to simplify the vaulting problem. But the rich sense of growth which the multi-ribbed pattern of vaulting produced is something none would regret. The nave of such a building as Exeter Cathedral is a wonderful display of ornate masonry. In other instances additional ribs were introduced in a still more obviously decorative way, forming starlike patterns in the vault surfaces. These are known as *lierne* ribs, characteristic of the later vaults of this century.

The Gothic Window

The development of the Gothic window is in itself extremely interesting. Early windows tended to be of minimum size, through two influences. The first was the disturbed state of the times, which made any opening in a building a weakness from the viewpoint of defence. The other was the scarcity and cost of glass. These influences became less and less pressing as medieval civilization advanced, so the tendency to increase the area of windows was progressive. The early Gothic window was a narrow slit, covered with a sharply pointed arch, taking its form from curves concentric with those of a wider and more bluntly pointed wall rib. The next stage was the grouping of these windows, called *lancets*, into pairs, threes, or fives, often conforming to the pointed enclosure by the raising of the central lights above the outer lights, more nearly to fill out the shape of the enclosing arch. A further development was to pierce the blank space in the point of the enclosing arch with some geometrical shape, such as a circle, a trefoil, or quatrefoil. This combined feature is known as *plate tracery*, and it is a design feature in which the shape of the opening, or void, is the keynote.

Fig. 1A Fig. 1B Fig. 1C

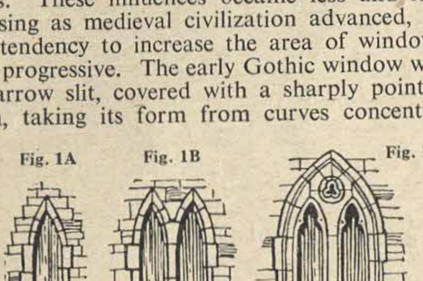
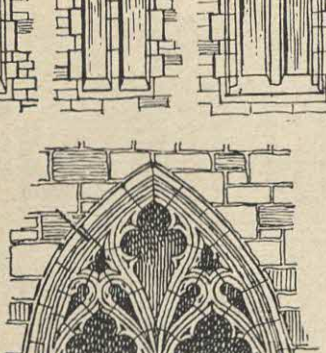
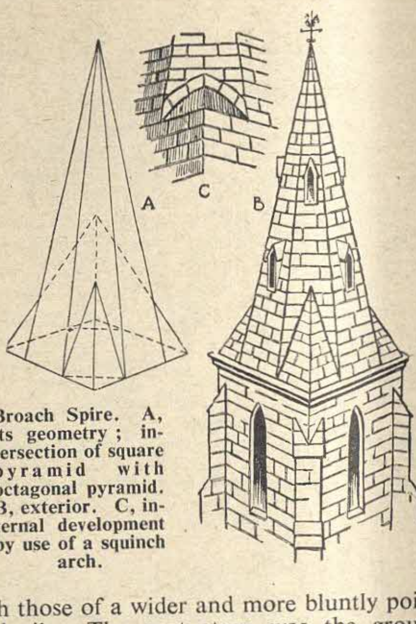


Fig. 2



Window Development. Fig. 1: A, single lancet ; B, coupled lancets ; C, plate tracery. Fig. 2. Bar tracery, showing flowing lines, enclosing shaped spaces.



Broach Spire. A, its geometry ; intersection of square pyramid with octagonal pyramid. B, exterior. C, internal development by use of a squinch arch.

Decorated Period of Gothic

In the next century, during the elaborating and beautifying period known as the Decorated period, a further advance in window design was made. In this, geometrical patterns were combined with a study of the flowing lines of the solids, and *bar tracery* came into being, taking the form of moulded bars of stone springing from the mullions, and interlacing in flowing lines within the main pointed arch, while still leaving interesting geometrical voids between them. Some of these patterns were of great beauty, and wonderfully skilful in their geometrical form. None but men of great artistry, as well as technical skill, could have produced such work ; and, if for no other reason, the Decorated period of English Gothic must be taken as within the live vital phase of Gothic architecture, and not as the beginning of a decline.

Early English doorways continued the main practices of the Norman builders, in the use of recessed arches, and the support of the rings, or orders, with little free columns, below the line of springing. But the appearance of these features was very different, particularly in the change from purely surface ornament in Norman work to the deeply undercut mouldings and enrichments of the 13th century. The arches took the form of alternating groups of bold projections, and deep grooves, the former being known as *bowtel* mouldings ; and a typical enrichment, known as the *dogtooth* ornament, is characteristic of this period in architectural development.

In the Decorated period the main process was also embellishment, with little change in the form of doorway, other than the enrichment of the arch with cusping and carving, and the development of more geometrical profiles to the mouldings.

Church Spires

The Early English spire is also a characteristic Gothic feature. The spire was generally octagonal, resting on a square tower, and the geometrical development from the square to the octagon in external effect is interesting. Internally, and constructionally, the change from one geometrical shape to the other was achieved by throwing arches, called *squinch arches*, across the corners of the square towers. Externally, one shape developed into the other in a clean, orderly way, by intersecting the tall octagonal pyramid with a lower square pyramid, which formed four gussets in the intermediate faces of the octagonal pyramid. This form of tower is known as the *broach spire*, and it persisted through the 13th and 14th centuries, except that in the latter the decorative effect was elaborated by the growing of angle turrets and pinnacles out of the broaches of the spire, so that it formed a cluster of finials with four lower points surrounding the main spire.

Thus Gothic Art took shape from purely practical steps in building, and then developed into a complex ornate system of design in which the structural origin was never entirely lost. It is this close and obvious kinship between structure and architectural form that makes Gothic architecture so satisfactory. In particular, the typical form of a Gothic cathedral—with clerestory windows throwing light into the heart of the building from within the ribs of the vault, and with buttresses arched over the aisles and loaded with pinnacles, taking the outward thrust of the vault—is honest structure at its best. No wonder that in the last century the Gothic Revival attracted many brilliant men. But the Gothic lesson, like the Greek, is of the spirit rather than the letter, and we cannot recapture the atmosphere of the Middle Ages.

LESSON 8

Gothic Architecture in its Decline

ARCHITECTURE in the 15th century is so full of interest, and presents such a wealth of beautiful examples, that it may seem strange to refer to this period as marking the beginning of a decline in English architecture. This period is to be regarded, in fact, not as one of inferior art but as one in which the driving energy of builders, with no new worlds to conquer in the field of structure, was working its way inexorably towards a state of temporary suspense in which the Renaissance found a fertile seed-bed.

The great Gothic inspiration, centred upon the vaulting problem, had produced a complete structural solution, to which the skill and devotion of masons had added their richest tribute, and the 15th century opened with little real pressure from the needs of building. The target for their energies was therefore limited, and the aim of the builders became more and more directed to appearance and less and less to actual structure.

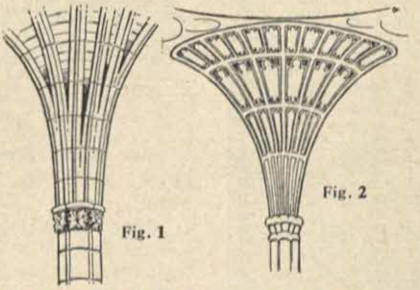


Fig. 1

Fig. 2

DECORATED AND FAN VAULTING.
Fig. 1. Decorated vault, showing irregular heights at which ribs part company. Fig. 2. Fan vault, with regular separation of ribs of equal profile and even spacing.

The vault had already become less dependent on ribbed construction, and more a continuous surface upon which the form of ribs marked the history of its development rather than its contemporary nature. It was natural then for the 15th-century builders to look for improvements in appearance, rather than in stability, or building method, in this still dominant feature. The multi-ribbed vault of the Decorated period was as nearly perfect in form as the Gothic method would allow. It had interest, strength, richness of effect, and regularity in its layout. The 15th-century masons could, in fact, find no fault in its appearance other than in one comparatively small detail. This was that in a 14th-century vault with intermediate ribs as it springs from a common pier between two vaulting bays, there are nine moulded ribs, including the wall ribs, springing from one source and fanning out at nearly regular intervals till they meet their respective ridge ribs. But the intervals between the pairs of ribs are not quite equal, nor are the curves of each pair identical. Thus the levels at which each pair of ribs parted company above the springing differed, and introduced a slight, but easily perceptible, irregularity, jarring to eyes which had turned from structure to appearance.

To such a small matter as this did the 15th-century mason apply his ingenuity, for he had by this time become well versed in the science of geometry. He knew that two things were needed to ensure that the clustered ribs above their springing from a common pier should be exactly spaced in regular interval and emerge free at a common level. These were (a) that they should have a common curved profile, and (b) that they should be evenly spaced, irrespective of the diagonal lines of the vaulting bay.

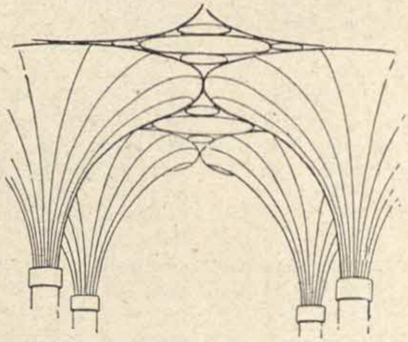
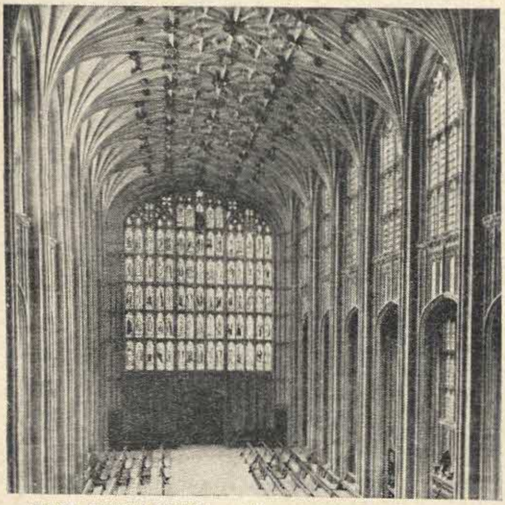


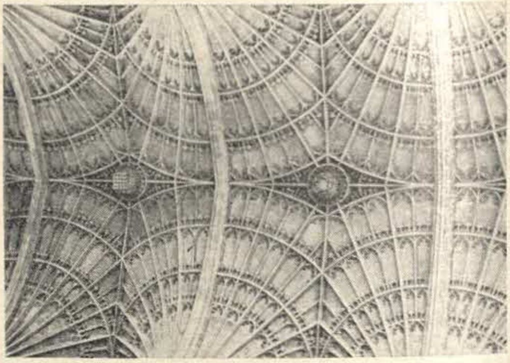
Fig. 3. Four cones of the fan vault with flat filling between.

Fan Vaulting

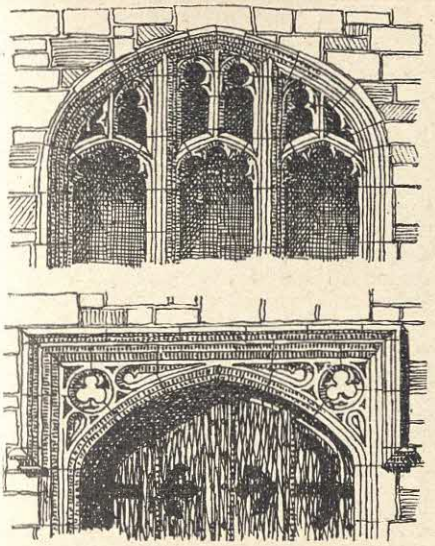
He accordingly arranged his vaulting ribs to conform with these requisites, and, as a result, finding that the level tops of these equal but radiating arches described a quadrant on plan, he joined their extremities with a quadrant level rib. The vault thus became, in each bay, four inverted hollow-sided cones, or parts of cones, which met tangentially, leaving a space between them. This space he filled with a flat panel of stone, with the joints wedge-shaped in the form of a level arch, forming interesting patterns. This *fan vaulting* was one of the most characteristic features of 15th-century architecture. It became a drastic revolution in vaulting method, since it finally removed the last vestiges of the groined vault by the omission of continuous diagonal ribs. It became, once and for all, a continuous vaulting surface upon which the forms of ribs were no more than a surface decoration, which gave no assistance to the builders, nor any escape from the need for complete centering while building.


FAN VAULTING. Characteristic feature of 15th-century architecture: a beautiful example in St. George's Chapel, Windsor Castle.

Some of the most beautiful examples are to be found at King's Chapel, Cambridge; St. George's Chapel, Windsor; and in the Henry VII Chapel at Westminster Abbey. The decorative ribs are linked with delicate surface tracery patterns, and, in the third of these three, all pretence of relation between structure and decorative form is thrown off by forming the bases of the fans as pendants extended downwards, from stones in the real structural arches which can be seen threading their way into the tracery. The decorative points of support seem to float in the air and create a delightful architectural fantasy, which makes no attempt to deceive, and thus forestalls the criticisms of those who profess to see in this a breach of the law of integrity in architecture.


FAN VAULTING. Superb example at King's College Chapel, Cambridge, showing how the ribs are linked with surface tracery patterns.

The movement for more light, which had already begun in the earlier periods, with the



PERPENDICULAR STYLE. Fig. 4 (top). Perpendicular window; the glass area is increased by raising the shoulder of the arch, and curvilinear work is reduced in restricted area. Fig. 5. Perpendicular doorway, showing a return to square lines.

14th-century bar-traceried window advancing far from the narrow early lancet, still proceeded. Such windows became wider and wider, until they filled the spaces between one buttressed point of support and another, and, at the same time, the shape of the pointed arch was flattened by striking its curve from four, instead of from two, centres (Fig. 4). In this process the wall of the church became almost a glass wall, with little more than the bare necessities of a stone framework enclosing the area of the glass.

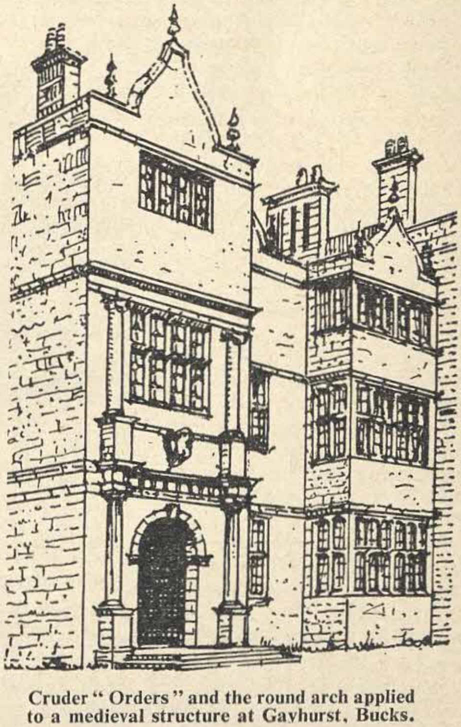
Perpendicular Style

The craft of glass-painting, or "stained glass," had developed rapidly, for pictures of saints and Biblical scenes made a strong appeal to a pious people who were mainly illiterate. The glass-painter preferred rectangular frames for his pictures rather than curved geometrical shapes ; and, as windows became larger, they were reinforced horizontally by stone transomes as well as by iron bars. The effect of a large window thus suggested a gridiron, and it initiated a move from the graceful and fanciful curved shapes of the late Decorated periods towards the rectilinear Roman forms that were revived during the Renaissance (Lesson 9). The surfaces of stone buildings and of wooden screens were similarly decorated with horizontal and vertical panelling : hence late Gothic work is called "Perpendicular" in England.

The whole character of architecture was changing rapidly from the massiveness of the Romanesque to a more slender grace, often carried to extremes which not only introduced an appearance of weakness, but actually led, in some instances, to collapse. The practical architectural sense of building was departing from design, and the Gothic style was losing the real vigour which had upheld it through three centuries.

Ornament, though lavish and magnificent, was also losing restraint and strength. The bold elemental growth of Early English carving had already become formalised in the 14th century, and in this last Gothic century it was becoming superficial and naturalistic, with the oak leaf and the grape vine as common elements. Doorways followed the shape of the window, with four-centred arches, often enclosed within a rectilinear drip moulding (Fig. 5), until, in the Tudor period, they closely resembled a horizontal lintel.

Towards the middle of the 16th century Italian craftsmen were operating in England, bringing with them the details of ancient Roman work which the Italian architects in their own country were already reviving. These were not designers, like their architect-masters at home, but workmen with new features of ornament, which they found easy to apply to English buildings. The crude pilasters they formed, to take the place of the buttresses, were crude imitations of the Roman Orders, and far more



Cruder "Orders" and the round arch applied to a medieval structure at Gayhurst, Bucks.

akin to the free Gothic architecture to which they were applied than to the strict formalism of the Roman style. They brought with them the Roman Orders, and also the round arch, which had never entirely disappeared from Italian work throughout the Gothic period.

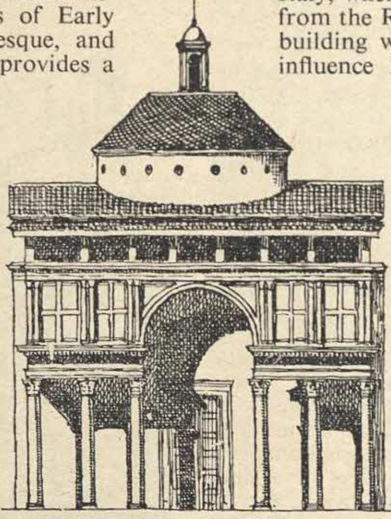
The Renaissance thus made its first slight impress upon English architecture in the form of applied ornament, as a fashion rather than a revolution in building. But it witnessed the arrival of the English architect, in the character of designer as distinct from master-craftsman, and thus nearer to the present conception of an architect than ever before throughout the Middle Ages. These men were induced to travel, and they found in Europe a leaning towards the ancient civilization which had made Rome a power in the world and of which abundant evidence remained in the classic ruins of Italy. This period of transition from late Gothic to the mature Renaissance architecture of Inigo Jones, described in Lesson 9, lasted from about 1540 to 1620 in London, rather longer in country districts of England. It is generally called "Tudor," "Elizabethan," and "Jacobean," in its various stages.

Very little church-building took place in England between 1540 and 1660, but there was great activity in erecting grammar schools, colleges, and handsome houses. The last are discussed in Lesson 13. Of this secular architecture in general it may be said that it is, for the most part, Gothic in form but Roman in its ornamental detail. It is picturesque, and distinctively English, displaying all the civilized comfort of the Elizabethan age after the rather gloomy austerity of the Middle Ages, but not producing any significant advance in structural knowledge.

LESSON 9

The Renaissance

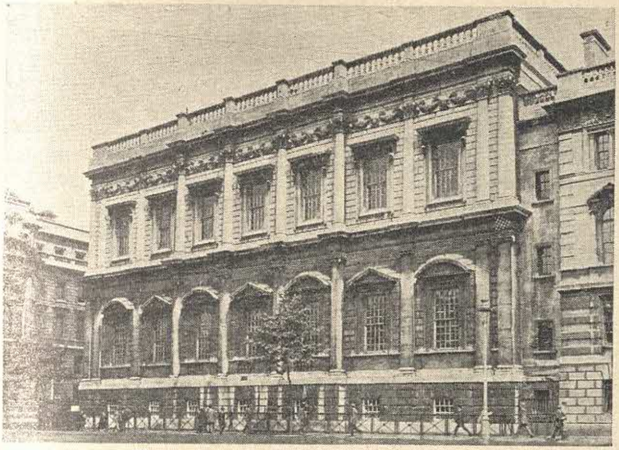
In these Lessons so far, and particularly throughout the Gothic period, it has been observed that architecture has been closely related to religion. The Greek temple was the central fact of that period ; the Roman temple was also important ; churches and cathedrals were the chief buildings of Early Christian, Byzantine, Romanesque, and Gothic architecture. Religion provides a spiritual stimulus such as is needed to produce great art. A further reason for this close association lies in the fact that throughout the Middle Ages learning, literature, the fine arts, and most of the crafts were in the hands of the Church, administered generally with conscientious benevolence, but sometimes oppressively, or at least repressively.



ROMAN STYLE REVIVED. The Pazzi Chapel, Florence, designed by the Italian architect Brunelleschi. It was from study in Italy that Inigo Jones absorbed the classic style.

Most medical books were written in the monasteries and beautifully illuminated, and were precious documents, not to be disseminated among a docile population. Culture became the perquisite of the few, and those few, in turn, lacked the broadening influence of a more democratic intercourse. The revolt against such a state of affairs was inevitable, and the introduction of the printing press provided a further influence towards an opening of the gates of knowledge. In the 15th and 16th centuries Europe was ripe for the awakening that took place, alike in the fields of religion, politics, and the arts. The Reformation and the Renaissance were parallel and closely related movements, both aiming at the fuller life that free knowledge offers. In the arts, the movement started in Italy, where a wealth of fine architecture from the Roman period was still visible, building which had never quite failed to influence Italian architecture. Although the seat of the Popes, Italy had also preserved a greater secular independence than the northern countries, through the powerful merchant states in to which the country was divided ; and the return to a study of the evidences of a great former civilization which lay around them was a natural movement carried on the crest of the broader awakening.

Brunelleschi, Peruzzi, Sangallo, Michelangelo, Palladio, and Vignola were some of the Italian master-architects who found among the classic remains of Rome a new inspiration for their art and recaptured the spirit of the ancient culture, adding to it their own artistry. The Pazzi Chapel by Brunelleschi at Florence affords an excellent illustration. Some of these architects, including Bernini, travelled to France and spread there the classic manner, a hint of which Italian craftsmen had already instilled into the Northern lands ; and architects from England and France



BANQUETING HALL, WHITEHALL. Designed in 1622 by Inigo Jones, it is the only portion of the Palace of Whitehall to have been actually built. It should be noted how column and pilaster are made to serve a gentle modelling out of the façade. Top right, detail of the frieze.

travelled to Italy to see the new style which had captured the Gothic field. Within two centuries the whole of Northern and Western Europe had been converted from the mystic qualities of Gothic art to the spacious civic ways of the Romans.

Inigo Jones

The most famous student of architecture from England who travelled abroad was Inigo Jones, who lived from 1573 to 1652. He visited Italy more than once as a young man, and became absorbed at once with the classic style, especially as interpreted by the great Italian architect Palladio. He returned finally to England in 1604, from which date his activities in the field of architecture were many and fruitful.

The most famous of his works is the banqueting hall in Whitehall. It stood on part of the site of a vast palace which was to have been erected between the Thames and St. James's Park. Though relatively small, this building is in its restrained treatment and fine proportions an example of the highest qualities of Renaissance architecture. Another of his works is the beautiful little Queen's House at Greenwich, 1617–35.

It is difficult at first to attune one's judgement to the Renaissance style, after the more obviously structural Gothic has been understood. In the latter the most dominant features, like the flying buttresses, the vaulting ribs, and the piers, were there because the stability of the building depended upon them. The Gothic building would collapse if stripped of its most characteristic features. But the Renaissance façade was often treated with an applied architecture.

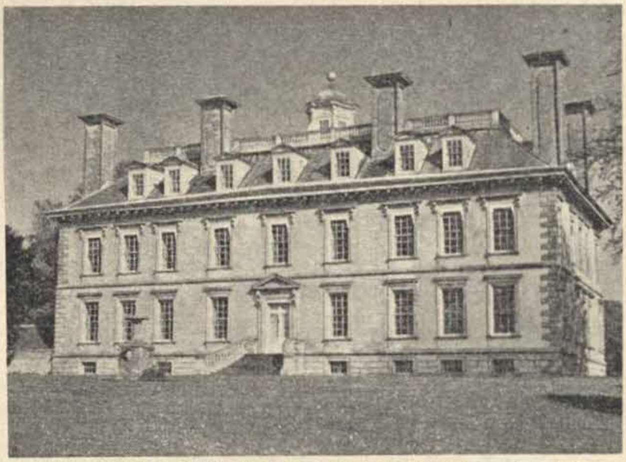
The banqueting hall, for instance, does not need its attached columns for support, although they are the most outstanding features of its façade. One may even wonder whether one is discussing the same art when one turns from the Gothic cathedral to such a Renaissance example as this, and, in a sense, one may conclude that one is not. It is not possible to compare one with the other in any competitive sense. One must rather compare their respective aims, and judge between them, if one must, by the measure in which they were attained.

The Gothic builders were great mason craftsmen, whose knowledge was limited to an inherited tradition of building, circumscribed by a simple way of living. Within that limited field they erected skilfully and with singleness of purpose the buildings needed for their ways of life and faith, and worked undisturbed by distant influences, and produced an architecture growing out of the soil of the country. But the Renaissance opened up much wider vistas, one looking back to a great civilization, the grand qualities of which were obvious in the work it left behind, another looking forward to a social scheme in which knowledge spread ever wider, and culture came within the reach of more and more classes of the community.

His Work and Influence

The banqueting hall in Whitehall suggests perfectly how these aspirations might find expression in the art of building. The superimposed Orders were ranged as the Romans would have ranged them, and express, at the same time, something of the civic dignity which took a new form as the Church released its monopoly of the arts. Those typical elements of classic design, the colonnade, the pediment, and the balustrade, appear as structural symbols of the Renaissance movement and form the language of classic design. Architecture had, in fact, become too broad in subject to be treated merely by the master craftsman, however important he remained within the limits of building. The art demanded a master mind free to choose the formal way of expressing the dignity of the new era. Inigo Jones, who occupied a position in relation to building not unlike that of the modern architect, was well fitted to take the lead, and he proved worthy of his charge.

But he was by no means a slave to Roman models, and there was always some individual



COUNTRY HOUSE OF THE 17th CENTURY. Coleshill, Berks, shows how the English country house has lost its last trace of medieval influence and become classic in feeling, although free of the classic Orders. It is attributed to Sir Roger Pratt, influenced by Inigo Jones. For ground plan see page 39.

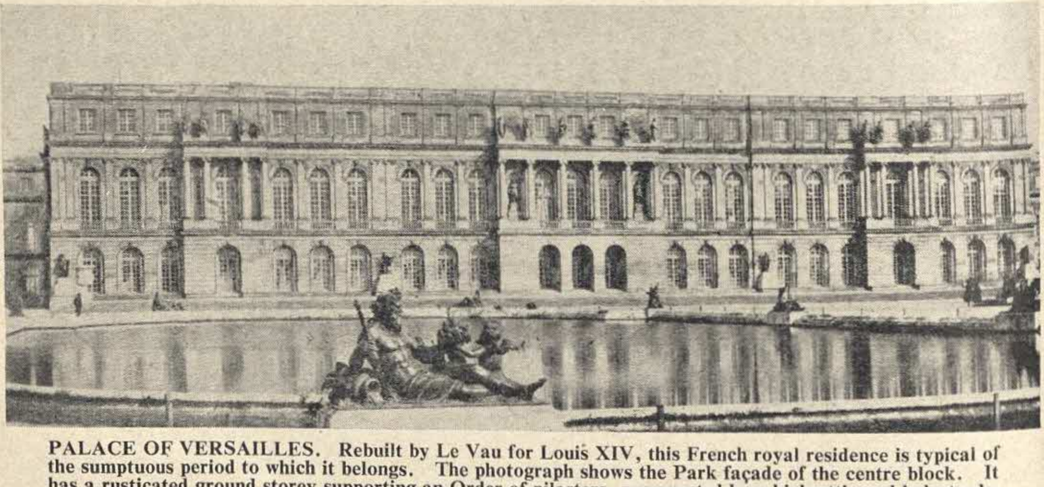
quality about his work, and a refinement of detail which few architects of the Renaissance could better. There is no example which shows this quality more clearly than his church of St. Paul, Covent Garden, London, though the building as it stands to-day is only a modern copy of the original built *c.* 1635. There, a simple portico of Tuscan columns is the dominant feature, but with a bold timber cornice and pediment crowning it in a most effective manner. It has been suggested that this feature was a rendering of the old Etruscan style of temple building, but it is very doubtful whether Jones's studies would have included such fragmentary work, and it is more likely that it was a spontaneous rendering of the classic theme in the mixed materials of stone and timber, in which his instinct for fitness caught the essential characteristics of both, to produce this charming and unusual result.

Inigo Jones also influenced the work of other contemporaries and pupils, who were bound to feel the ascendancy of a designer of such power and ability, and particularly John Webb, whose work at Greenwich Hospital has all his master's quality, and Sir Roger Pratt, to whom Coleshill, Berks, is attributed, a house in which the dignity of classic work has been applied without the use of Orders, and which shows a marked development from Elizabethan planning towards the formal style which was to come.

There is no doubt that but for the Commonwealth, when he suffered as a Royalist, the works of Inigo Jones would have been more varied and numerous. But it is unlikely that his reputation as a pioneer of the Renaissance movement in England could have been higher than it is, for he is recognized by all authorities as the first and in some ways the greatest English architect, well fitted to rank with Palladio in Italy and Le Vau in France, as one of the Masters of the Renaissance.

Sir Christopher Wren

Some sixty years junior to Inigo Jones, Sir Christopher Wren was a worthy successor. He was a remarkable man of many accomplishments, as famous in the world of science as in the art of architecture. Adopting the latter profession comparatively late in life, and, studying in France at the time of the rebuilding of the Palace of Versailles by Le Vau, he gained at second hand an insight into the classic movement



PALACE OF VERSAILLES. Rebuilt by Le Vau for Louis XIV, this French royal residence is typical of the sumptuous period to which it belongs. The photograph shows the Park façade of the centre block. It has a rusticated ground storey supporting an Order of pilasters, surmounted by a high attic and balustrade.

which Italian architects—in particular, Bernini—had brought to that country. Wren's detail was less studied and refined than that of Inigo Jones, as judged by Italian classic standards, but there is no doubt that he brought into English architecture a distinctive personal feeling so appropriate to the national taste that he was able to round off the great work which his predecessor had initiated, by firmly establishing an English classic tradition. The originality of Wren was not of the kind that starts a passing fashion, but had that quality of soundness which lasts. It is true that his opportunities were many, and greater than those presented to Inigo Jones; but none but a great man could have grasped them with both hands so successfully as did he.

The Renaissance thus takes shape as a wide social movement in which the individual and personal element occupies a place more prominent than in any previous architectural period. It presents some difficulty to the student of architecture by appearing less spontaneous a movement than others he has studied, it is no doubt the idea of "revival" that accounts for such a feeling. But the Renaissance must be understood in relation to the history of Europe. Nothing so complete and dignified as Roman civilization had happened in the material field before. Christianised Europe for centuries had lived a static day-to-day existence.

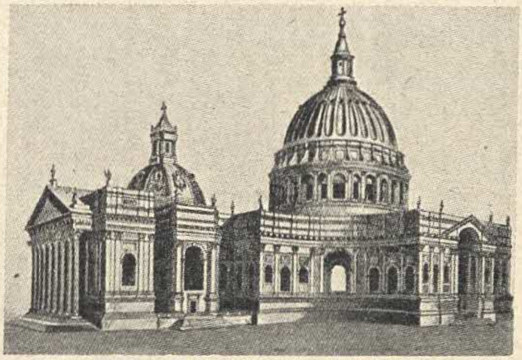
It was therefore the most natural thing in the world that men made newly alive to the broader spiritual and intellectual issues confronting them should turn to the ancient culture for the means of expressing the fuller life and the progressive course of civilization.

LESSON 10

The Work of Sir Christopher Wren

SIR CHRISTOPHER WREN (1632–1723) was one of the great figures of the European Renaissance, and in many ways he succeeded more fully in expressing fine architecture in classic terms than any of his contemporaries and immediate predecessors. Wren succeeded in combining academic knowledge with the creative instinct, towered above many eminent figures, and was over-shadowed by none.

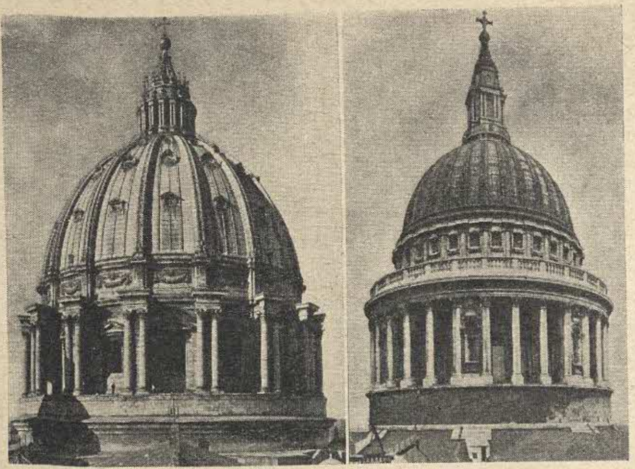
The amazing range and quality of his works was accounted for not only by opportunities on a scale few others enjoyed but by his energy and versatility. And his early training gave him a knowledge of geometry and mechanics invaluable to an architect. The work of Inigo Jones had already made the classic style familiar and, though Wren made contact with the Italian and French masters in France to enrich his architectural knowledge, he had no new tradition or manner to create when, after the Great Fire of London in 1666, he began to rebuild much of the city.



DESIGN FOR ST. PAUL'S CATHEDRAL. **Wren's second and favourite design for St. Paul's Cathedral, of which he had a wooden model made. This model is still to be seen at St. Paul's.**

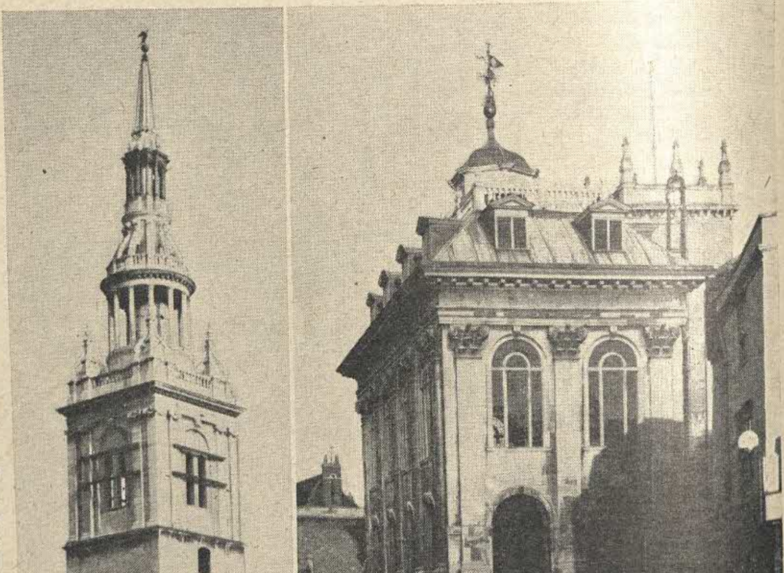
St. Paul's Cathedral

At this date Wren was still a professor of astronomy, 34 years old, and his work as an architect hitherto had been confined to the Sheldonian Theatre at Oxford and a college chapel at Cambridge; but he had been consulted about the repair or rebuilding of the old (Gothic) cathedral of St. Paul's before the Great Fire destroyed it. His first design had included a rather hideous dome on the old Gothic church, but after the Fire had made complete rebuilding inevitable he produced a second design, on revolutionary lines, with a large central dome on a "Greek Cross" plan; and he had a wonderful wooden model made of it, which is still to be seen at St. Paul's. (Between these two designs he had prepared another, of which a battered model also exists, but it need not be described here.) His favourite, the "Greek Cross" design, with four arms, was rejected by the clergy because they considered it untraditional, and unsuited for processions. Wren therefore prepared a final scheme with a long nave, a long chancel, and transepts—in fact, the normal plan of a Gothic cathedral in spite of its magnificent central dome; and it is this design which was actually built between 1675 and 1710. Undoubtedly one of the world's finest buildings, its merits may be best appreciated by comparing it with another great domed cathedral equally famous—St. Peter's at Rome. The first point in which St. Paul's surpasses this building is in the way Wren expressed its scale, as distinct from



TWO GREAT DOMES COMPARED. Michelangelo's dome of St. Peter's, Rome (left). Wren's dome of St. Paul's, London (right). In grace of outline, unity of scale with the substructure, handling of the peristyle of the dome, and in the building up of the base, Wren's masterpiece excels.

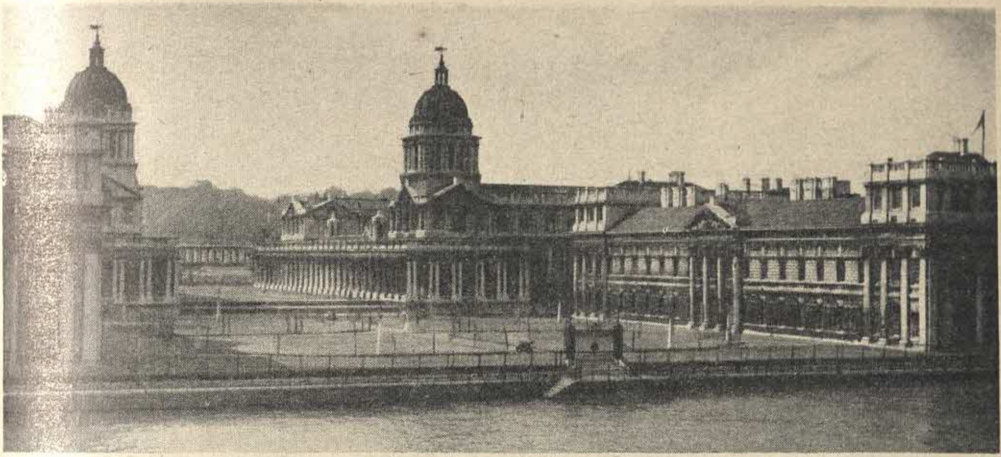
mere size. St. Paul's is very much smaller, but the actual building, inside and out, does not give any impression of this disparity. At St. Peter's, one giant Order was used. Wren did not make this mistake, but superimposed two Orders on the outer walls of St. Paul's, thus emphasising their height, and setting a note of scale which he could maintain throughout his design.



THE STAMP OF WREN'S GENIUS. The steeple of St. Mary-le-Bow, Cheapside, London (left), is one of the most successful of the graceful steeples Wren designed. Abingdon town hall, Berkshire (right), is an example of a country town public building showing how Wren's influence spread far beyond the fashionable cities.

The dome of St. Peter's also tends to look too low externally, although internally there is an uncomfortable feeling of excessive height in the great central domed space. Wren was well aware of the difficulty of designing a dome which would be effective from both without and within ; so he placed his main stone dome at a height at which it would give the maximum internal value, erecting above it a timber dome covered with lead, over which rose the stone cupola or lantern, which he carried on a pyramidal brick cone between the outer and inner members. In this way he produced an exterior feature the proportions and outline of which are unsurpassed, while preserving the majestic internal effect without which a building must fall short of greatness.

Other masterly touches added greatness to St. Paul's. The four square staircase turrets which occur in the internal angles on the crossing result in a feeling of mass abutment round the base of the dome and give it an added air of stability. Again, in the treatment of the beautiful peristyle of the dome itself, by filling in certain of the spaces between pairs of columns he preserved the grace and delicacy of the colonnade, without injuring the effect of strength by too great a show of daylight between column and drum. The plan of the cathedral round the great domed space is also to be admired, for it is one of the few examples where full advantage has been taken of a three-aisled plan to form a great congregational space at the focus of the interior. Ely Cathedral, Cambridgeshire, is the only ancient Gothic



GREENWICH HOSPITAL. This notable Thames-side building, five miles below London Bridge, consists of several groups. The earlier ones were built by Charles II from designs by Inigo Jones and John Webb. The later groups, built by Queen Anne and William III, were designed by Wren and Vanbrugh, the layout being such as to embody the earlier unrelated buildings into a magnificent symmetrical scheme.

cathedral in England where this arrangement has been followed. In each example an octagon has been formed by throwing diagonal arches across the width of the side aisles, so that the central space occupies the full width of nave and aisles.

If Wren had never built St. Paul's, his other works would still prove him to have been a great architect. Of these, there are none more interesting than the 51 City churches which he rebuilt. They are marked by skill in planning upon sites of irregular shape tucked in among commercial buildings. Many have spires designed in the Italian style, with outlines of singular grace and beauty.

Wren's Secular Buildings

Wren's successful handling of brickwork in the classic setting is delightful, particularly in the fine garden façade of Hampton Court Palace, Middlesex, which links so pleasantly with the older Tudor brickwork, and provides evidence of the inevitable harmony between buildings of good style however different in period. Here are those typically English elements, the brick wall and the well-proportioned sash window, forming a natural alliance with Roman architecture, and setting a standard for the simple dignity of the smaller country houses that were to follow. Wren was a great planner. There is more than a touch of genius in the way he grouped the newer buildings of Greenwich Hospital so as to form a magnificent axial layout, which embodied the earlier and hitherto unrelated buildings, with the Queen's House as the centre. But still more will Wren's planning abilities be remembered by the plan for the rebuilding of London, which he produced after the Great Fire in 1666. As explained in Lesson 15, where the plan is illustrated and described, his scheme was never carried out, owing to practical obstacles and vested interests.

Outside the London area there are many other works, great and small, which bear the stamp of Wren's genius, some by his own hand, others obviously due to his advice. The town hall at Abingdon, Berkshire, is one of such works, believed to have been the result of his close influence, and the Orangery to the north of Kensington Palace, London, is a joint work of Wren and Vanbrugh, designed with a mastery of materials and style.

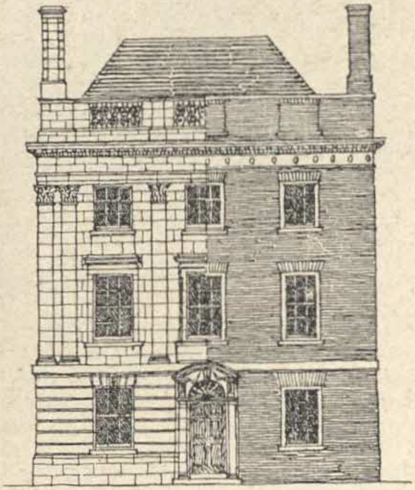
Wren was less happy when he used the Gothic style in some of his City churches; but in these instances the style was forced upon him by circumstances or by his employers. Among all his varied talents, the most important quality he showed was his deep understanding of building. St. Paul's was no academic paper design, shaped to some preconceived fancy; it was a great building, the structure and balance of which were never out of the designer's mind. It was in every way adequate, and it stood secure until a careless generation allowed deep excavations in its vicinity to undermine its natural foundation. Stability has now been restored, and the building which most typifies the greatness of English Renaissance architecture stands fast.

This brief account of a great architect would not be complete without reference to the pupil most closely associated with him, Nicholas Hawksmoor (1661–1736), who followed Wren in practice. Hawksmoor lacked the sure touch and taste of his master, but in such works as St. George's, Bloomsbury, and the London church, St. Mary Woolnoth, he followed the new traditions, and showed skill as a designer.

LESSON 11

The Eighteenth Century in England

WHEN the 18th century opened, the Renaissance style was already firmly grafted on to our national architectural tradition, and it had penetrated from the capital and the Court into remote country districts where the use of mullioned windows with casements, steep roofs, bold chimneys, and half-timber construction had lingered on from Gothic times. During the Georgian period, which began just before Wren's death in 1723, the use of classical architecture in these byways and backwaters became almost universal, so that Georgian buildings in quiet country places, especially in the old market-towns, display a high standard of design, chiefly due to the use by builders and craftsmen of books containing rules and illustrations of design compiled by architects and others; for the majority of these modest buildings were not architect-designed. Georgian architecture of this simple sort, in spite of its Italian origin and its frequent use of the Roman Orders, is distinctively English, and many of its characteristics can be traced to the influence of Wren's work.



Development of the typically English 18th-cent. façade. The left half shows the full dress of classical formality, developed by Inigo Jones and Wren after their studies abroad; the right half shows the same dignity and feeling expressed in plain brickwork.

In all Georgian buildings—large and small, plain or magnificent—the façade was formally and symmetrically designed on classical proportions. In the more important buildings, classical pilasters (flat columns) were applied to the brick or stone façade and stood on a podium or plinth formed by the lowest storey. They were crowned with a cornice and a balustrade in the Roman style. Behind the balustrade there were usually dormer windows to light rooms in the attic. In smaller and plainer buildings, often of brick, the pilasters, cornice, and balustrade were omitted; but the proportions remained unaltered.

Sash-windows formed part of the formal design, and were usually taller in the first-floor rooms than in the other storeys, the first floor containing the principal rooms, as in Italian Renaissance palaces of the 16th century; but all windows were of uniform width and were placed exactly one over the other in all the storeys. The semi-Gothic window of the 17th century, with its stone or wood mullions and transoms, and its leaded casements, was replaced by sash-windows at the close of that century, sash-windows often being inserted into existing window-openings in place of the older type. The sash-window was a marked improvement on the casement-window. It was more weather-proof; it provided more easily controlled ventilation at top and bottom; its larger panes and wooden bars admitted more light; in ground floor rooms it did not project over the pavement when it was opened; and

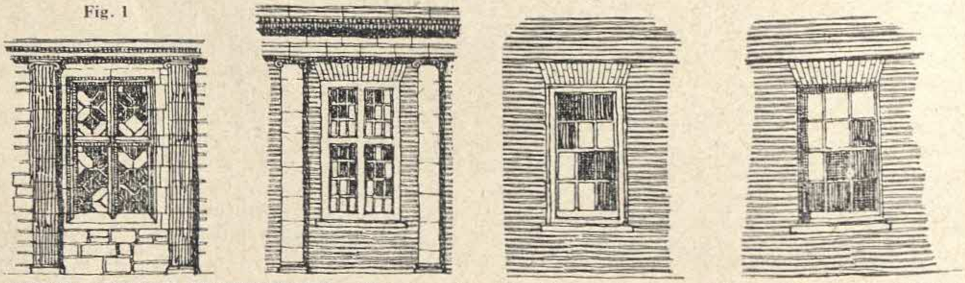


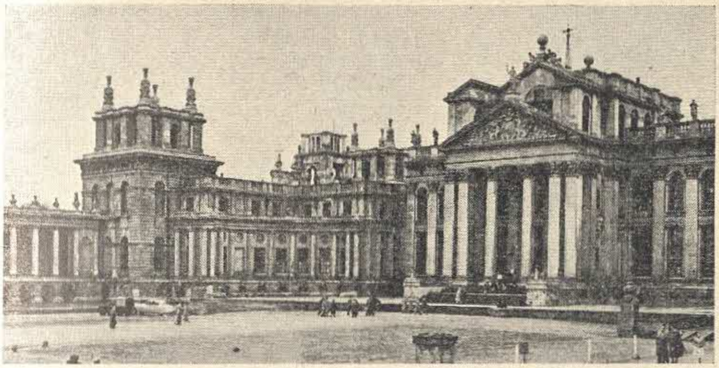
Fig. 1

Fig. 2

Fig. 3

Fig. 4

DEVELOPMENT OF WINDOWS. Fig. 1, medieval traditions of stone mullions and transoms within a crude framework of classic suggestion (Elizabethan). Fig. 2, wood mullions and transoms in proportions conforming with a classical formality (middle 17th cent.). Fig. 3, sash windows in similar proportions, completing the simple national style in classic terms (early 18th cent.). Fig. 4, recessed sash window, losing last traces of framed work and becoming simply a well proportioned opening (late 18th cent.).



BLENHEIM PALACE. Residence of the Dukes of Marlborough, near Woodstock, in Oxfordshire, Blenheim Palace has a frontage of 850 feet. It was designed by Vanbrugh (1664–1726), who was a colleague of Wren in designing part of Greenwich Hospital.

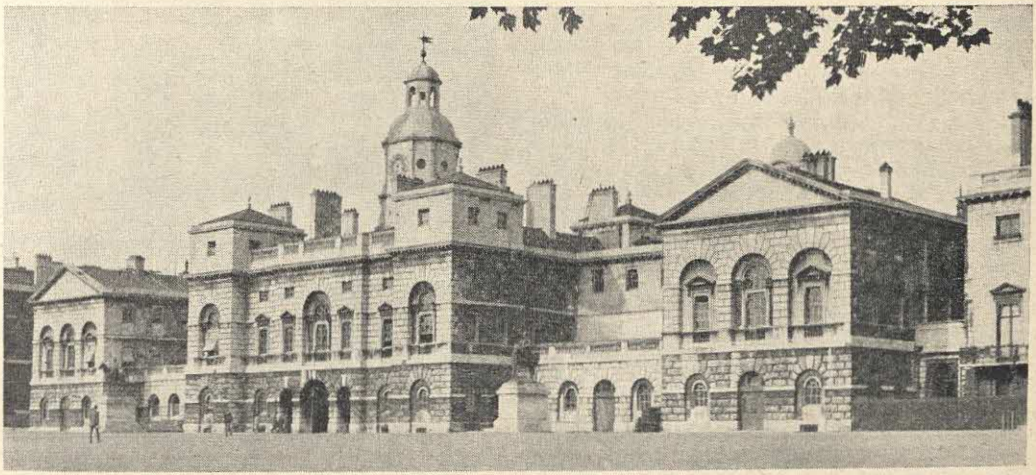
it harmonised better with a classical façade. In the smaller and plainer buildings there were no cornices or architraves or even moulded sills round these windows, and often the only feature to relieve the austere façade was a delicately designed doorway flanked by graceful iron railings and lamp-standards.

Georgian Mansions

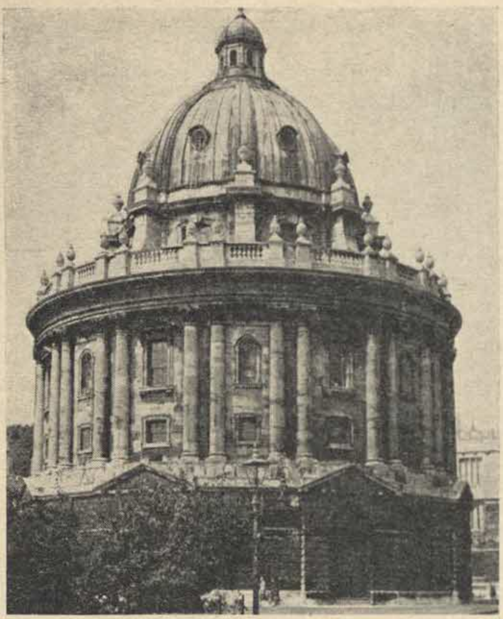
The 18th century was an aristocratic age in England as in France, and a large number of enormous mansions were erected all over the country by rich noblemen and profiteers. All these huge buildings were planned on monumental lines, i.e. very formally and symmetrically. Each contained a suite of vast state-rooms opening one from the other, so that at Castle Howard, Yorks, it is said that one can look through the keyholes of the connecting doors for a distance of 350 feet. With its wings containing stables and kitchens respectively, this colossal dwelling has a frontage of 700 feet, but Blenheim Palace, in Oxfordshire, is even longer—850 feet.

Both buildings were designed by Sir John Vanbrugh (1664–1726), a soldier who was also a successful dramatist who turned architect, and became a colleague of Wren in designing part of Greenwich Hospital and the Orangery at Kensington Palace. He was the chief exponent in England of the ostentatious and magnificent "Baroque" style of architecture then in vogue over most of Continental Europe; and, as might have been expected, he treated architecture in a dramatic way rather than on practical lines derived from structural principles and social needs, and his design of details was forceful rather than refined. One of his best works was Seaton Delaval, in Northumberland.

In all these mansions, at a period when labour was plentiful and wages low, the servants had to sleep in badly lighted attics or basements, and even the lavish meals for the rich owners had to be carried along cold corridors from remote kitchens to the splendid dining-room, for everything was sacrificed to display. Other huge mansions of the first half of the 18th century were Moor Park in Hertfordshire, by the Italian Leoni; Houghton Hall in Norfolk, by Colen



HORSE GUARDS, LONDON. This government building, of which the west façade looking on to the Parade Ground is shown here, was designed by William Kent. It consists of a central block, with a clock tower over an arch in the Whitehall façade, and two wings, and shows a fine sense of massing and proportion.



RADCLIFFE LIBRARY, OXFORD. This Renaissance domed building was designed by James Gibbs, the architect also of St. Martin-in-the-Fields and St. Mary-le-Strand, famous London churches.

Campbell ; Wentworth Woodhouse in Yorkshire, by Flitcroft ; Harewood House in Yorkshire (afterwards decorated by Adam), by John Carr ; Prior Park at Bath, by John Wood, who also laid out much of that beautiful city ; and Holkham in Norfolk, by William Kent. The last-named architect was a protégé of the connoisseur and amateur architect, Lord Burlington, who, with his help, designed the older parts of Burlington House in London, and a splendid " villa " at Chiswick in the style of the Italian Renaissance. Kent also designed the Horse Guards in Whitehall.

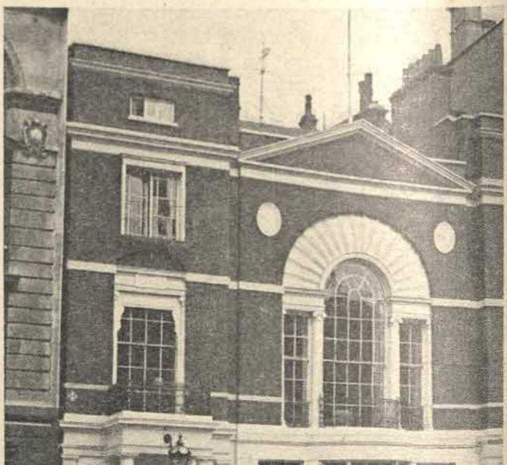
James Gibbs, a contemporary of the architects just mentioned and a follower of Wren, designed two London churches with handsome steeples—St. Martin-in-the-Fields, and St. Mary-le-Strand. His magnificent domed Radcliffe Library at Oxford is illustrated here. In Cambridge he is represented by the " Gibbs Building " at King's College.

Chambers, Adam, and Soane

The second half of the 18th century in England was dominated by the work of three outstanding architects—Sir William Chambers, Robert Adam, and Sir John Soane. Chambers began as a poor boy, but assiduous study made him a great authority on architectural scholarship and a most successful architect. Apart from his books on design, he became famous as the designer of Somerset House, between the Strand and the river in London. The construction of the Thames Embankment in Victorian times, and the subsequent rebuilding of Waterloo Bridge, have detracted from the splendour of the riverside front.

Robert Adam was one of several sons of a Scottish architect. These brothers settled in London, Robert being the most prominent, and created a very large practice in England as well as in Scotland. Their style was more delicate than that of Chambers and Gibbs, borrowing many ideas from recent discoveries at Herculaneum in Italy. The interiors of Robert's numerous mansions were beautified with dainty plasterwork in relief, beautifully coloured. Kenwood, near Hampstead, is one of his finest mansions. He also designed town houses in London. The façade of Boodle's Club in St. James's Street, London, though actually designed by James Crunden, is typical "Adam style."

Sir John Soane, who, like Chambers, started in humble circumstances but became famous, is best known as architect of the Bank of England in London. It contains a sequence of noble rooms planned with much originality ; but the appearance of his building has been much altered in the 20th century by the addition of a tall central block, of which it now forms the base. At his death, in 1837, he bequeathed his



BOODLE'S CLUB. Boodle's, in St. James's Street, London, is a typical example of the " Adam style," but this graceful façade was actually designed by James Crunden.

fine house in Lincoln's Inn Fields, with all his collections of artistic treasures, to the nation. It is now known as Sir John Soane's Museum.

As was remarked in Lesson 8, very little church-building took place in England between 1540 and 1660, though a great number of imposing Baroque churches were erected in the Roman Catholic countries of Continental Europe. At the Reformation the Church of England had cut itself off from Rome and had become Protestant. For the next hundred years and more there was ample accommodation in the existing parish churches for a population that had become less dependent on the clergy; moreover, many churches of the dispossessed monasteries had been converted into parish churches. The 16th century in England, as elsewhere in Europe, was a disturbed period, with Roman Catholics and Protestants in conflict; and the Civil War in the 17th century created further religious dissensions.

Change in Church Design

The boom in rebuilding London churches after the Great Fire of 1666 caused Wren, a thoughtful man, to consider whether the old-fashioned type of church, originally built in the Middle Ages for the Roman Catholic type of ritual, was appropriate for Protestant worship of a different type. He came to the conclusion that it was not, put his ideas into writing, and carried them out in rebuilding the old City churches and in building several new ones elsewhere, e.g. in St. James's, Piccadilly. The new type of church that he devised became the model for other architects throughout the 18th century. Although altars were provided, special prominence was given to preaching, and Wren insisted that everybody in the church must be able to see and hear the parson. Partly with that object, partly because of the cramped sites in the City, he was compelled to provide galleries in certain churches, much as he disliked galleries as such. He also made a special point of ample lighting.

SOMERSET HOUSE, LONDON. One of the most mature of English classic buildings, Somerset House, lying between the Embankment and the Strand, was designed by Sir William Chambers, an authority on the classic style. The photograph was taken from the entrance into the courtyard giving on the Strand.

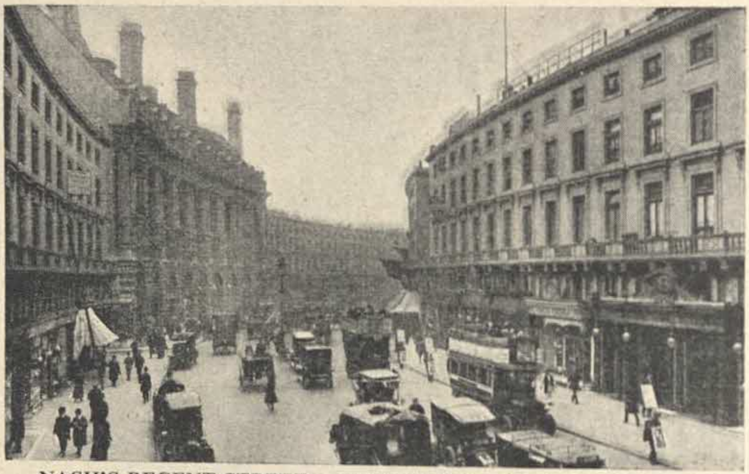
These new ideas were adopted not only by the Church of England, together with the "squire's pew" and its cushioned comfort, but also by the various nonconformist bodies which, originating in the reign of Elizabeth I, had become numerous during the 17th century, and sufficiently powerful (and free) at its close to start building their own churches, chapels, or "meeting-houses" as they were then called, in all parts of the country.

LESSON 12

The Nineteenth Century in England

THE first third of the 19th century, up to Queen Victoria's accession in 1837, produced "Regency" architecture, so called because it was closely associated with the Prince Regent, who became George IV in 1820. He was a great patron of the arts and spent money lavishly on buildings, and John Nash was his favourite architect. Regency architecture is to be seen at its best in London, especially in surviving buildings of the splendid scheme of streets which Nash laid out between the Mall and "the Regent's Park"—including Waterloo Place, Regent Street, and the fine terraces round that park. Much of Brighton (Sussex), Weymouth (Dorset), and St. Leonards (Sussex) was laid out in the same style during the same period.

Regency architecture represents the last phase of the classical or Georgian or Late Renaissance tradition in England. Like the work of Robert Adam described in Lesson 11, it was derived from Greek as well as Roman architecture; but most of its buildings were faced with stucco instead of stone. Some people regard stucco as a mean material compared with real stone, and it certainly looks shabby unless it is frequently painted; but there is something very bright and attractive about a Regency façade freshly painted in a cream colour. John Nash (1752–1835) designed the dignified old Regent Street that many people still remember, but its graceful buildings were all demolished in the early 20th century to be replaced by taller



NASH'S REGENT STREET. John Nash designed a fine London town-planning scheme which included Regent Street, with its colonnaded quadrant and the curving sweep of shop fronts shown above, leading to All Souls, Langham Place, and thence by way of Portland Place to Regent's Park, with its palatial blocks of symmetrical architecture.

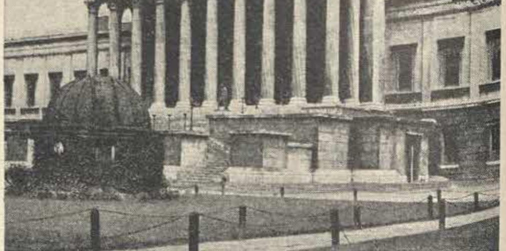
stone buildings more suited to modern commercial demands. Nash's Carlton House Terrace still remains, and he built most of Buckingham Palace, though the front to the Mall was rebuilt from designs by Sir Aston Webb as part of the Queen Victoria Memorial in 1913.

At Brighton, Nash forsook the Regency style when he designed for the Prince the bizarre Pavilion in a curious blend of Chinese and Moorish architecture ; and occasionally he built mock-medieval castles or sham-Gothic villas, as in Park Village, on the east side of Regent's Park. Other prominent architects of the period were Decimus Burton, whose finest work is the Athenaeum Club in London, 1829 ; and William Wilkins, whose Downing College at Cambridge, 1820, and University College in London, 1828, are more successful than his National Gallery, 1832–38.

Gothic Revival

Abreast of all this building in the Regency style, another very different type of architecture was being produced in England. Although Gothic architecture had been practically discarded by the time of Inigo Jones, early in the 17th century, it had lingered on here and there, especially in Oxford, where Hawksmoor's queer Gothic towers at All Souls College are even later. In 1750 the connoisseur Horace Walpole amused himself in building a mock-Gothic castle for his own occupation at Strawberry Hill near Twickenham ; and sundry other wealthy noblemen actually constructed sham ruins in their parks. This revived interest in the Middle Ages was mainly confined to eccentric aristocrats and scholars until an architectural draughtsman, Augustus Pugin, and his more celebrated son, Augustus Welby Pugin, began publishing books of drawings of Gothic architecture early in the 19th century. During the previous hundred years few new Anglican churches had been built in England; but something of a boom started after 1818, when an Act of Parliament was passed voting a million pounds for that purpose ; and of 214 churches erected between 1818 and 1835 under that Act, 174 were in Gothic or near-Gothic style. A good example is St. Luke, Chelsea, 1820–24.

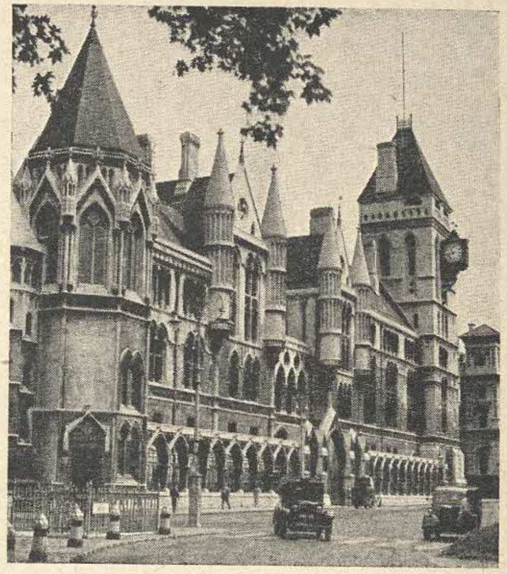
This sudden craze for Gothic was at first confined to churches ; but when the old Palace of Westminster was burnt down in 1835, the government, in arranging a competition for new Houses of Parliament, ruled that designs must be in Gothic or Elizabethan style, in order to harmonise with Westminster Abbey hard by. The competition was won by Charles Barry with a fine plan on the same classical lines that he had hitherto used for mansions and clubs, but clothed in Gothic details, for which he enlisted the help of Welby Pugin as a Gothic expert. This magnificent building was the first important structure to be erected in England in the revived Gothic style ; and from that date



CLASSIC PORTICO. University College, London, designed by William Wilkins in 1828, is a fine building in the classic style, with a remarkable portico.

onwards, for forty years, a "Battle of the Styles" was waged, in all European countries as well as in the U.S.A. and in British colonies, between the supporters of the Gothic and the Classic styles.

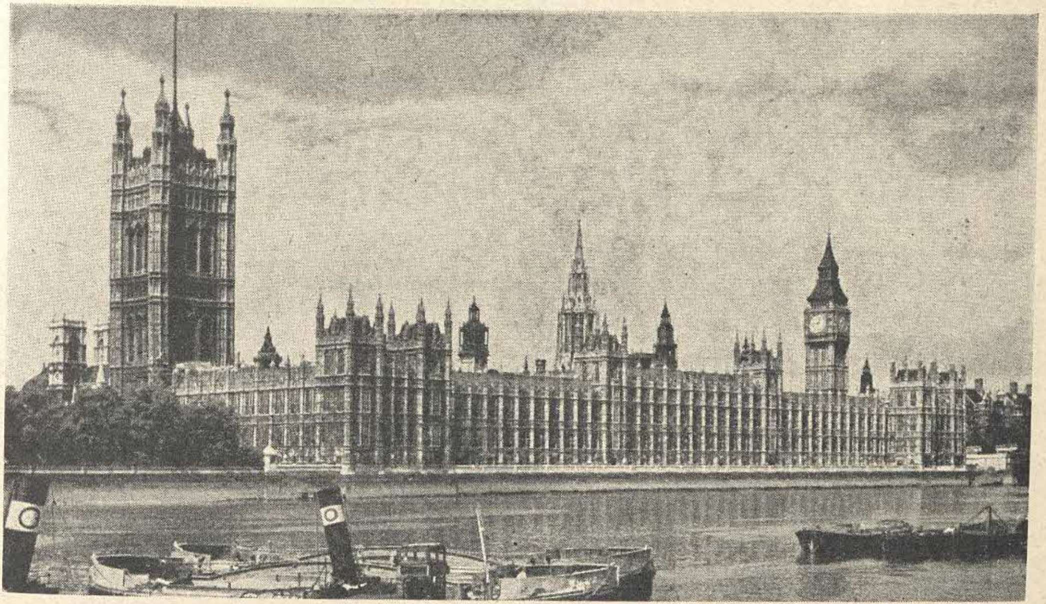
The last great public buildings in the Gothic style in England were the Town Hall and Assize Courts at Manchester, by Alfred Waterhouse, 1864–68; the Law Courts in London by G. E. Street, 1874, and St. Pancras Station in London, 1865, where Sir Gilbert Scott designed a florid and un-English Gothic hotel as its frontispiece. The writings of John Ruskin (1819–1900), who had a great admiration for French and Italian Gothic, helped to develop an English taste for these foreign styles of architecture. The influence of the Gothic Revival spread all over the country, until not only town halls and hospitals and railway stations but also rows of speculative builders' villas came to be decked out with pretentious medieval ornament; and the plain meeting-houses of the various nonconformist bodies were replaced by inappropriate "chapels" with tall spires and traceried windows, in an effort to comply with the prevalent fashion.



LAW COURTS, LONDON. Designed by G. E. Street, the Royal Courts of Justice, in the Strand, were the last great attempt to apply the revived Gothic style to a modern public building.

Machinery and Housing

The Industrial Revolution which began in the 18th century was unfavourable to the revival of all these medieval ideas, derived from an age when craftsmen worked individually by hand. Ornament was now duplicated by machinery, iron had become an important factor in construction, and social conditions were entirely different from those of medieval times. The Great Exhibition of 1851 displayed a vast array of hideous machine-made goods, but it was housed in a wonderful structure of glass and iron

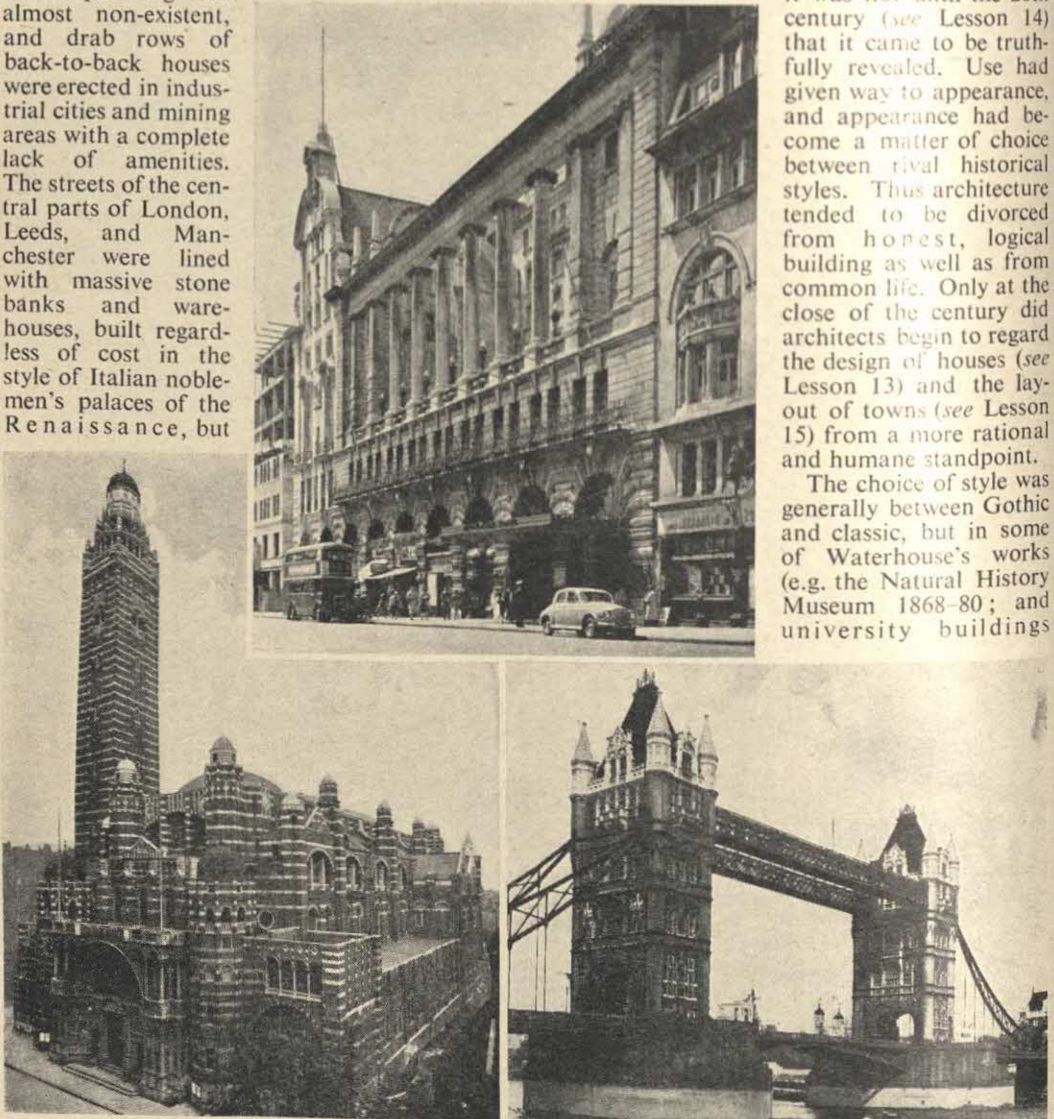


HOUSES OF PARLIAMENT. The Palace of Westminster (to give the building its correct name), designed by Sir Charles Barry, is classic in inspiration but Gothic in style, and the architectural detail adheres scrupulously to the Tudor period.

which was afterwards removed from Hyde Park and re-erected at Sydenham as the "Crystal Palace." This was a significant milestone in architectural history.

Yet while notable discoveries were being made in structural engineering, lighting, sanitation, and other fields of knowledge connected with building, architects were far too much concerned with the "Battle of the Styles" and far too little with artisan housing and other practical matters. Town planning was almost non-existent, and drab rows of back-to-back houses were erected in industrial cities and mining areas with a complete lack of amenities. The streets of the central parts of London, Leeds, and Manchester were lined with massive stone banks and warehouses, built regardless of cost in the style of Italian noblemen's palaces of the Renaissance, but wanting in adequate light and ventilation. Public libraries were equally funereal, and even hospitals were provided with Venetian Gothic tracery which collected soot and excluded sunshine. In Leeds there is a brick factory-chimney copied from the famous 14th-century marble campanile of the cathedral at Florence. Iron girders were used in nearly all these buildings, but nothing in the appearance of the buildings gave any indication of that fact: it was not until the 20th century (*see* Lesson 14) that it came to be truthfully revealed. Use had given way to appearance, and appearance had become a matter of choice between rival historical styles. Thus architecture tended to be divorced from honest, logical building as well as from common life. Only at the close of the century did architects begin to regard the design of houses (*see* Lesson 13) and the layout of towns (*see* Lesson 15) from a more rational and humane standpoint.

The choice of style was generally between Gothic and classic, but in some of Waterhouse's works (e.g. the Natural History Museum 1868–80; and university buildings



Westminster Cathedral (left), great Roman Catholic church in London, designed by J. F. Bentley, is a brilliant essay in Byzantine architecture; it illustrates the academic way in which style had come to be treated in the latter part of the 19th century. London's Piccadilly Hotel (top), designed by Norman Shaw; the classic detail of this building is rendered in a free and romantic way typical of the start of the 20th century. Tower Bridge (right), opened in 1894, was designed by Sir Horace Jones and Sir J. Wolf Barry: it has been described as "machinery in a pair of Gothic trousers."

at Manchester, 1870; Leeds, 1878; and Liverpool, 1885), a modified form of Romanesque was adopted; and terracotta was mostly used. Bentley's great Roman Catholic Cathedral at Westminster, 1894 onwards, was a brilliant essay in Byzantine architecture. T. E. Collcutt, though using Renaissance detail, showed much originality in his design of the Wakefield Town Hall, 1880, and especially in his Imperial Institute in London, 1893, with its graceful tower.

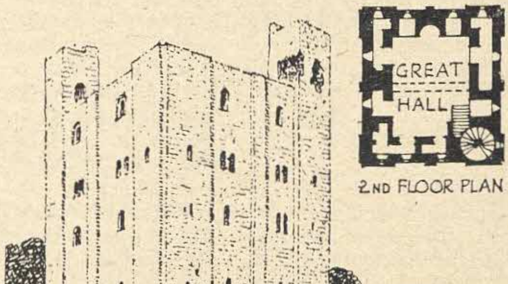
Norman Shaw (1831–1912) was the outstanding architect of the late Victorian period. His most important work was in the domestic field, but his building at New Scotland Yard, 1887, shows originality. His design of the Piccadilly Hotel formed part of his proposed rebuilding of the Regent Street Quadrant, but was carried out just after the end of the 19th century, in 1905. At that date Gothic was the fashionable style for all new churches, classic of a free and exuberant type for all public buildings and banks; and a change was beginning to become apparent in the design of office-blocks, factories, and flats and dwelling-houses.

LESSON 13

The English House up to 1900

PREVIOUS Lessons have dealt with architecture in general, the last six of them confined mainly to England; and most of the examples described have been buildings of some size and importance. Yet the methods of design, construction, and decoration, in each style and period, applied equally to dwelling-houses large and small. In this Lesson a more detailed description is given of the planning and development of the English house as such, with special reference to changes in its design caused by changes in social life and manners.

In the Middle Ages the so-called " middle class " hardly existed. There were the great feudal lords in their massive stone castles, the monks in their monasteries, and the poor folk in their flimsy shacks hardly deserving the name of cottages. Not until Tudor times did a prosperous yeoman class begin to build houses of materials sufficiently durable to ensure their survival to-day. The few remaining examples of what might be called " middle class " dwellings include the stone-built "Jews' Houses" at Lincoln and Bury St. Edmunds, and various stone manor-houses.



CASTLE HEDINGHAM. A typical Norman keep, in which military defence was the keynote, and domestic arrangements, so far as they existed, were of the most primitive kind.

Norman Keep

Nearly all the castles built in England between 1066 and 1100 consisted of earthworks and palisades. Among the exceptions which included a stone " keep " or central fortress was the Tower of London. Of other examples erected in the first half of the 12th century one of the finest keeps is at Castle Hedingham in Essex, *c.* 1140. It is a huge stone tower, about 60 ft. square and rather more in height; not so large as the enormous keep at Dover or the " White Tower " in the Tower of London. It is four storeys high, each storey containing a single large room.

A keep formed the last refuge of a garrison when the enemy had forced the outer defences of the " bailey " or surrounding fortified courtyard. On the lowest floor of such a keep were storehouses, and sometimes dungeons (prisons); on the principal floor were the quarters of the feudal lord with his family; the upper floors accommodated the men of the garrison. Everything was sacrificed to the needs of defence, and there was very little comfort. Windows in the thick walls were mere unglazed slits, giving very little light. Provision for sanitation comprised small chambers containing latrines and called " garderobes," in the thickness of the outer walls. As a rule there was one huge fireplace on each floor. In some keeps each storey was divided into two rooms by a cross-wall; in others there are small bedrooms in the thickness of the outer walls; occasionally there is a private chapel. Fortresses of this kind continued to be built up to the end of the 13th century. In striking contrast to the massive castles were the hovels of the populace, generally constructed of rough branches laced together, plastered with mud (wattle-and-daub), and roofed with thatch. They had no glazed windows, no sanitation, no comfort.

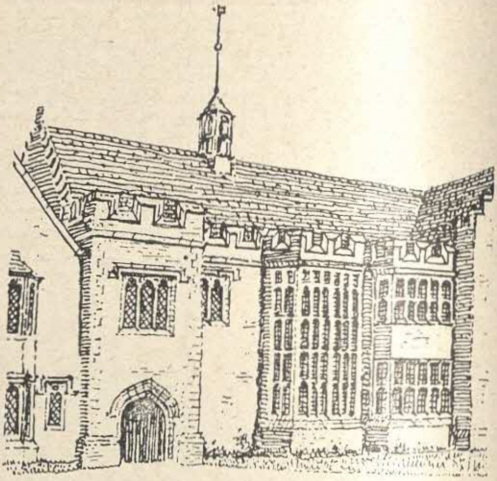
Early Manor-Houses

The rare examples of small manor-houses that have survived from the 13th and 14th centuries were sometimes moated, but not fully fortified. Each of them invariably contained one large room, the hall, in which the owner, his family, and his servants all cooked, fed, and slept under rather uncomfortable conditions. The single open fire burned on a central open hearth, the smoke rising up to the lofty open roof, which was sometimes provided with a ventilating turret. The floor was covered with rushes, which needed frequent renewal. There was no glass in the narrow windows, no plaster on the rough walls, and hardly any furniture. In the larger fortified manor-houses which replaced the Norman castles after the 13th century separate kitchens and pantries were provided, entered from one end of the hall and sheltered from it by a screen. The next step was to build a private bedroom for the owner at the other end of the hall.

Then came the introduction of window-glass, of fireplaces against the wall with flues leading to a chimney-stack, of tapestry on the walls, and of a private sitting-room—the " solar "—opening out of the hall. By this time, the need for defensive measures had passed. Windows were enlarged, but battlements were often still provided merely for decoration, as on some of the older colleges at Oxford and Cambridge, where they never served any defensive object.

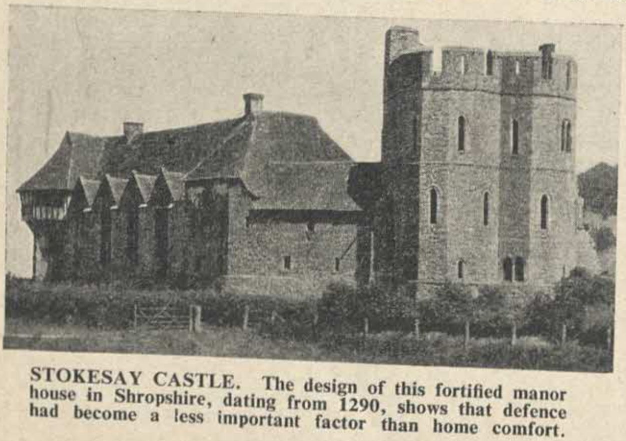
Tudor Buildings

Such was the general arrangement of the larger manor-houses at the dawn of the Renaissance, early in the 16th century. The first effects of that movement, as explained in Lesson 9, consisted in the addition of scraps of Italian ornament to the Late Gothic homes of noblemen or rich merchants who wished to display their knowledge of the latest London fashions in architecture. More important was the change in habits of life among the upper classes. Many wealthy men had travelled abroad, and had seen in France or Italy a standard of comfort, elegance, and culture far ahead of anything in England. No longer were English ladies and gentlemen content to eat and sleep in the smoky, smelly, dirty conditions of the great hall. They wanted privacy, plenty of light and air, warmth, colour, refinement, and dignified surroundings. So windows were enlarged, and divided by mullions and transoms into glazed lights filled with heraldic glass, ornate stone chimney-pieces were installed in galleries and parlours lined with beautiful oak panelling, elaborate modelled plasterwork enriched the ceilings, chimney-stacks became things of beauty ; and, outside the house, formal gardens enhanced its attractions.

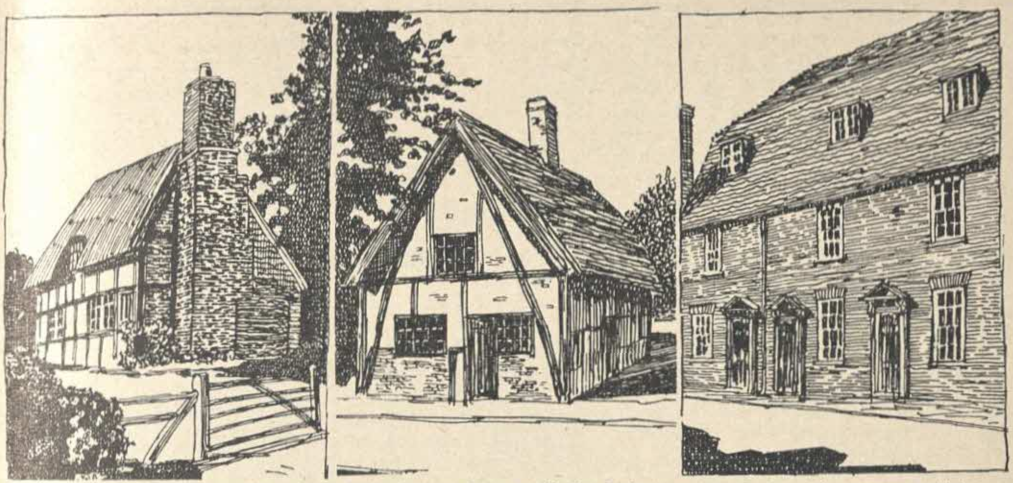


HORHAM HALL, ESSEX, an Early Tudor house—mullioned windows, mock battlements.

Meanwhile the Tudor age saw a great improvement in yeomen's houses and cottages. The latter usually contained two rooms on the ground floor, with a central chimney-stack. A steep narrow staircase led up from an entrance-lobby to two or more bedrooms, often partly in the roof. These cottages and small houses were always simple in design and often of some beauty, differing according to the materials available in each locality. Stone was used in West Yorkshire, in the "Cotswold" limestone belt from Dorset to Lincolnshire, in Cornwall and Devon, and in West Sussex.

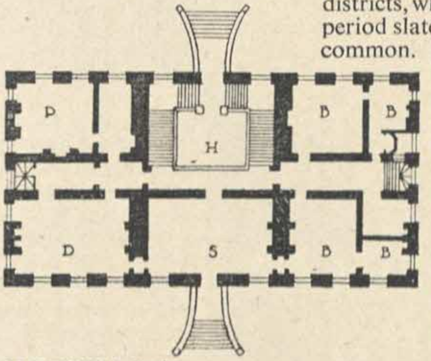


STOKESAY CASTLE. The design of this fortified manor house in Shropshire, dating from 1290, shows that defence had become a less important factor than home comfort.



ENGLISH COTTAGES. From Elizabethan times until the Industrial Revolution (the process which changed England from an agricultural to a manufacturing country in the latter half of the 18th century and the beginning of the 19th and produced squalor and slums) most English working people were housed in a manner dignified if modest. Many picturesque survivals still grace the countryside. Left, typical 16th-cent. timbered cottage at Eardisland, Herefordshire. Centre, "cruck" construction at Sutton Bonnington, Notts. Right, 18th-century cottages at Farnham, Surrey, showing classic suggestions in detail.

Timber framing was used especially in the west Midlands and in the eastern and southern counties. Some of the earliest timber cottages were of "cruck" construction; i.e. with naturally curved timbers used in pairs at each end of the building, and sometimes intermediately too, forming the shape of the letter A with a cross-beam to hold them together. The feet of the crucks rested on a brick or stone plinth or on a wooden sill at ground level, and their tops were joined at the roof-ridge, so that roof and wall-timbers were all in one piece. The cross-timber or tie supported the floor of the upper storey or attic. The windows of Tudor cottages were invariably small casements, usually with leaded panes. The mullions were either of wood or of stone, according to locality. Roofs were generally covered with thatch or shingles, except in stone districts, where thin stone slabs were used. At this period slates were almost unknown and tiles uncommon. Brick cottages were also unusual: they are seen mainly in the eastern counties. Timber-framed buildings were filled with wattle-and-daub panels, less often with brickwork; or were plastered all over (as in East Anglia) or covered with weather-boarding (in the Home Counties).



COLESHILL, Berks. The plan shows complete emancipation from the medieval manner. H, hall; S, salon; D, drawing-room; P, parlour; B, bedrooms. See also picture in page 26.

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Returning to the larger country-houses, a change took place, during the 17th century, from a plan still centred on the great hall, and sometimes consisting of rooms grouped around a quadrangular court, to a formal arrangement of handsome rooms approached from a spacious entrance-hall and wide staircase, as at Coleshill in Berkshire, 1650. The splendid mansions of the wealthy, from this period onwards, for nearly two centuries, are described in Lesson 11, where mention

CASTLE STREET, Farnham. No. 62 in this street shows an orderly façade of the late 18th century, in which the Renaissance style has become essentially English in character.

is also made of smaller Georgian houses. During the Victorian era, almost up to its end, English domestic architecture showed a decline in quality. The larger houses, though equipped with gas and even bathrooms, tended to be pretentious in design, over-decorated with carved or machine-made or painted ornament.

This fussy decoration spread into the rows of small villas and terrace-houses erected mainly by speculative builders without the help of architects, but copying architect-designed ornament from the larger houses. The planning of Victorian streets and suburbs is dealt with in Lesson 15.

A change for the better in the design of houses and cottages began when the teaching of William Morris (1834–96), inspired to some extent by Ruskin, led to a move back towards honest, rational, simple building of a definitely English character, free from pretentiousness and over-decoration; but little progress was made in either domestic architecture before 1890, or in municipal housing or town-planning before 1900.

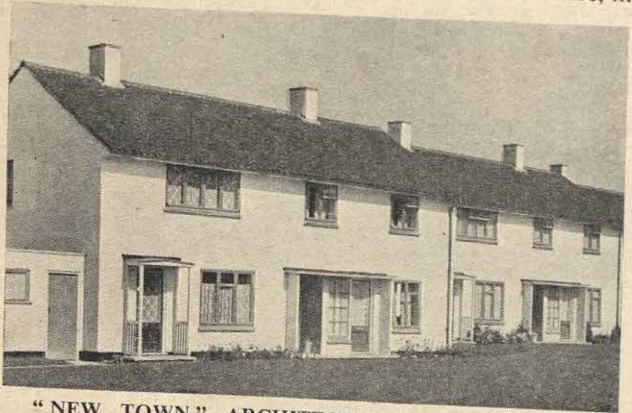
LESSON 14

The Twentieth Century

THE first years of the new century, up to the outbreak of the First World War (1914), were in many respects the most prosperous in English history, and a sense of proud splendour is evident in what may be called "Edwardian" architecture. Typical public buildings of the period in London are the Victoria and Albert Museum, 1909; the County Hall, 1908–22; the Central Hall at Westminster, 1904; and the Port of London Building, 1912. Selfridge's store in Oxford Street was erected in 1909. Farther afield, the magnificent City Hall and Law Courts at Cardiff were built in 1899–1905, and the grandiose City Hall at Belfast in 1906. In remote Calcutta the glory of the British Empire was proclaimed in the imposing Victoria Memorial Building, 1906–21.

"Edwardian" Architecture

All these huge stone structures, with their domes and porticoes, were in some form of that Roman Renaissance style which Norman Shaw used at about the same time in his design for the Piccadilly Hotel (Lesson 12). They showed no sign of the changed methods in building due to the recent invention of reinforced concrete, and no hint of the so-called "modern movement" in architecture which was soon to reach England from the Continent. The new Anglican cathedrals at Liverpool and Guildford were both designed in the Gothic style, in 1904 and 1930 respectively. The revolution in architecture had barely begun in 1914.



"NEW TOWN" ARCHITECTURE. Mid-20th-century trend in domestic architecture is given full scope in the new towns developed to take overflow population from old towns which have no room to expand. These houses are at Bracknell New Town, Berks.

Dwelling-houses, however, were no longer decorated with sham-Gothic ornament or provided with traceried windows; and even the revived-Elizabethan house with mullioned windows had given place to revived-Georgian with sash-windows, though the speculative builders' villas continued to be somewhat pretentious. One pioneer in the simplification of English house-design was C. F. A. Voysey (1857–1941), who created a new type with long, low casement windows, rough-cast walls, steep slated roofs, and bold chimneys capped with black pots. The charming house—"The Orchard"—that he built for himself at Chorley Wood, Hertfordshire, in 1900 is typical of his style, based on the tradition of the English cottage, and very original, though perhaps too consciously rustic.

Le Corbusier and Others

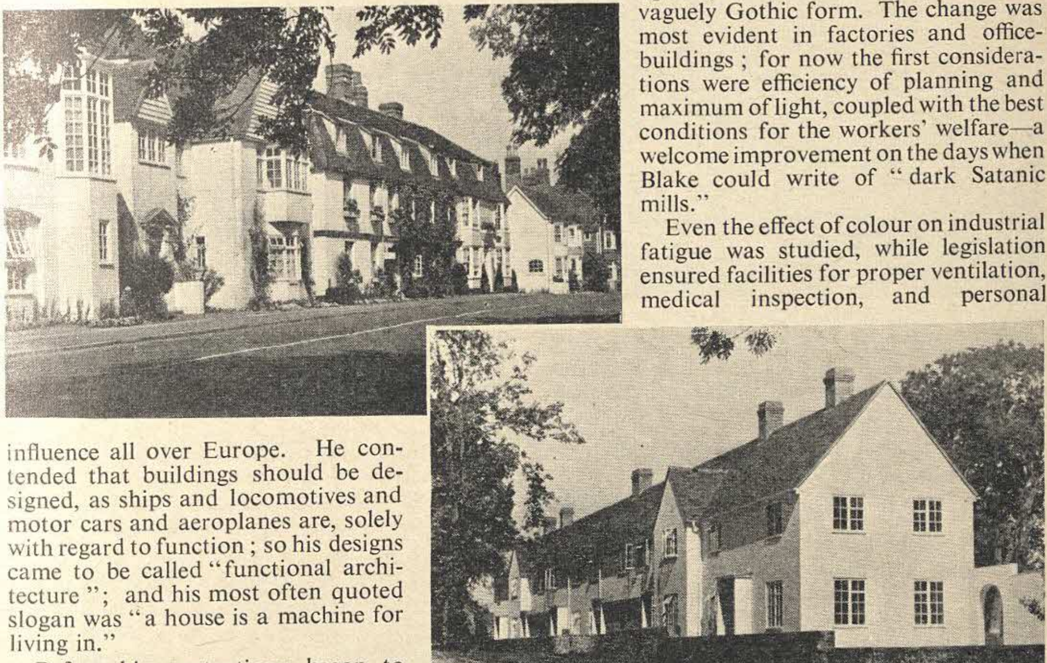
In the early years of the 20th century Voysey's work was attracting much attention in Continental Europe; but, at the same time, far more revolutionary ideas were being hatched out across the Channel. In Germany, Holland, and Belgium, and particularly in France, architects were now attempting to get rid of the historical styles—both classic and Gothic—and to produce a modern style of architecture based on new methods of building and new ways of life. One leader of this movement was the German architect Walter Gropius (b. 1883), while in France the most prominent figure was a Swiss architect, Charles Édouard Jeanneret (b. 1887), who chose to adopt the pseudonym of "Le Corbusier," by which he has been known ever since.

In Paris and elsewhere, from 1922 onwards, Le Corbusier erected several houses and other buildings of austere design, constructed of steel, concrete, and glass ; faced with rough-cast ; having very thin walls and partitions, flat roofs, and a complete absence of 19th-century fussiness. Until later years his output of actual buildings was relatively small ; but his two published books, on architecture in 1923, on town planning in 1923, had an enormous influence all over Europe. He contended that buildings should be designed, as ships and locomotives and motor cars and aeroplanes are, solely with regard to function ; so his designs came to be called "functional architecture"; and his most often quoted slogan was "a house is a machine for living in."

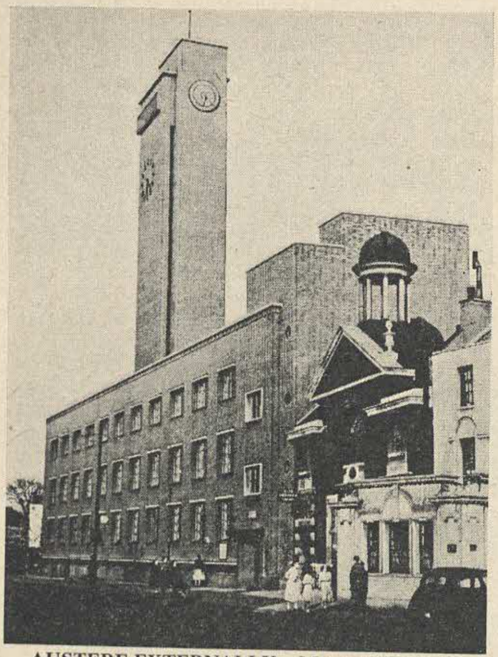
Before his contentions began to affect English architecture seriously in the 1930s English architects were already discontinuing some of the Classical features so popular in the gorgeous Edwardian era, such as the huge columns that decorate town halls and even shops of that period. The "economy campaign" resulting from the First World War may have been one cause of that tendency ; but the American practice of setting back the upper storeys of skyscrapers in order to give light and air may have influenced the designers of the London Transport headquarters over St. James's Park station, 1929–33, and of the noble Senate House of London University, 1933–39. Both these buildings have flat roofs, but their walls are of masonry with windows of normal size, not glass screens between slender pillars of steel or reinforced concrete. The *Daily Express* building in Fleet Street, 1932, displays a daring façade of black glass, metal, and ordinary glazing.

Many of the municipal buildings erected between the two world wars were even more austere externally, e.g. the county halls at Chichester, Dorchester, Hertford, and Taunton ; and the town halls at Hornsey, Watford, and Wembley. Some railway stations, too, particularly those rebuilt on the London Underground system, felt the breath of fresh air from across the Channel. Many new churches were now designed without spires, tracery, pinnacles, or other medieval trappings, and were adequately lighted, even when they preserved a vaguely Gothic form. The change was most evident in factories and office-buildings ; for now the first considerations were efficiency of planning and maximum of light, coupled with the best conditions for the workers' welfare—a welcome improvement on the days when Blake could write of "dark Satanic mills."

Even the effect of colour on industrial fatigue was studied, while legislation ensured facilities for proper ventilation, medical inspection, and personal cleanliness—notably in pit-head baths for miners. Office-workers likewise benefited from the new solicitude shown for their welfare. During the decade before the Second World War a number of able architects entered Great Britain from Germany as political refugees ; and though many of them subsequently migrated to America, they left their mark on England by designing remarkable buildings (e.g. the De La Warr Pavilion at Bexhill, 1936),



IN ANCIENT WINCHELSEA. Eighteenth-century houses and inn (top) in German Street, Winchelsea, Sussex, where new houses (lower), designed by A. H. Neave, have been erected. Some stone for the new houses and their low garden walls came from demolished houses reputed to date from about the end of the 13th century. The present town was planned by Edward I; the original town was engulfed by the sea in 1287.



AUSTERE EXTERNALLY. Many of the municipal buildings erected in England between the two world wars were designed on severe lines. Greenwich Town Hall, with its soaring, angular tower, was completed in 1939.

sometimes working in partnership with English architects. They also helped to spread the austere gospel of Le Corbusier.

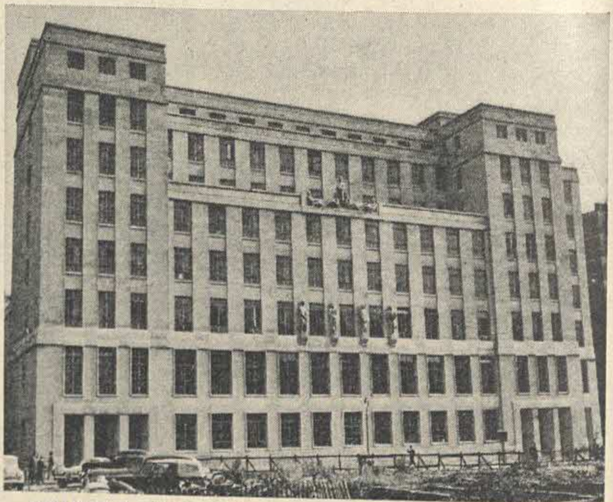
Reinforced concrete was now fully appreciated ; not only was it fireproof, as evidenced in the City of London at the time of the air raids of the Second World War, but it had other valuable qualities. It could be fashioned into very thin lids or vaults of any required shape, and into cantilevers (brackets) strong enough to support the whole upper part of a building as a projection overhanging the lower part. Concrete balconies could thus be constructed easily and economically by this method, an important point in the building of residential flats.

The building experience of England after the First World War had more effect on town planning than on architecture; the erection of temporary factory-made " pre-fabs " after the Second World War solved an urgent problem that could not have been solved in any other way. Municipal housing and the " New Towns " are discussed in Lesson 15. Flats are more popular abroad than in England, where a majority of people prefer a small house with its own garden ; but flats are essential in the crowded and costly inner quarters of cities, for those who must live near their work ; and they have certain other advantages. In most large modern housing schemes flats are provided as well as other types of dwelling, terrace houses often being built in preference to the semi-detached type so popular between the world wars ; for the latter sort occupy too much agricultural land, and, by increasing the area of each estate, also increase the time taken in daily journeys to and from work.

New Look in Schools

School architecture had made much progress between the world wars, and flat-roofed buildings with enormous windows filling most of the wall-area were replacing the old-fashioned dark Victorian schools with their mullioned windows and those obsolete features vaguely associated with education in the days of the Elizabethan grammar schools of the 16th century. The new schools were admittedly difficult to keep warm, and the type adopted after the Second World War even more so, because the buildings were spread so widely over the site ; but great strides in school design have been made since 1945 (notably by the Hertfordshire County Council) in devising a comprehensive range of standard units, which can be prefabricated and brought ready-made to the site.

It seems fitting to close this Lesson with a brief analysis of the new architecture in the middle of the 20th century. Many of its characteristics differ from anything seen in the



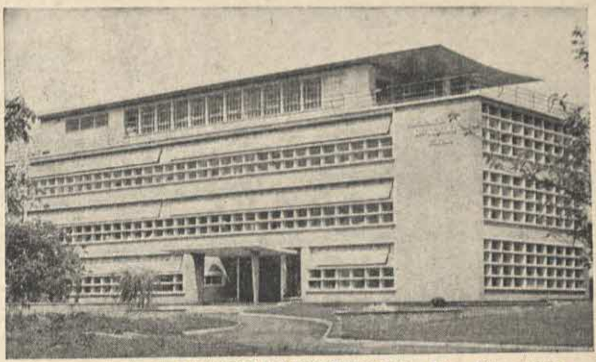
STARKLY UTILITARIAN. Some ultra-modern office buildings carry the " new look " uneasily. These business premises in Walbrook, London, with upper storeys set back, are to some extent relieved by ornamental figures.

preceding periods and styles ; but, merely because it seems strange, it does not follow that it is inferior as architecture. The work of Inigo Jones must have seemed odd to his contemporaries, and most of the work of the Victorian architects is disliked or despised by their sons and grandsons.

The flat roof, for instance, apart from any question of appearance, has both merits and defects. It facilitates planning because it is simply a plain lid of any desired shape, pierced for chimneys, of which there is often only one in these days of central heating ; whereas a sloping roof involves much scheming, and the more chimneys there are the more difficult the scheming becomes. On the other hand, a flat roof requires first-class workmanship to render it waterproof, and special precautions to insulate the rooms beneath it against heat and cold. White concrete walls look very attractive when they are new, but here again first-class workmanship and materials are needed to prevent the cement from cracking, and they must be painted or whitened periodically to look smart. Enormous areas of glass are better than mid-Victorian gloom, but the rooms which they illuminate may be far too hot in summer and very costly to heat in winter.

Thus the modern type of building is not invariably above criticism on practical grounds, but it need not be ugly, and indeed can be most attractive when designed by a skilled architect with the gift of imagination.

The modern building, however, fails as architecture when it is nothing more than " a machine for living in," or working in, or worshipping in ; and when it is just a dreary duplication of standardised and prefabricated units without a single bit of ornament or moulding or any relieving feature whatever. However admirable may be the proportions of the building, there is a point at which the human spirit rebels against mere nihilism and wants to be cheered up.



TWENTIETH-CENTURY EFFICIENCY. The offices of the contractor, Sir Robert McAlpine and Sons, on the Hemel Hempstead, Herts, site selected for development under the New Towns Act, 1946. It was to provide accommodation for a population of 60,000, with complementary industries.

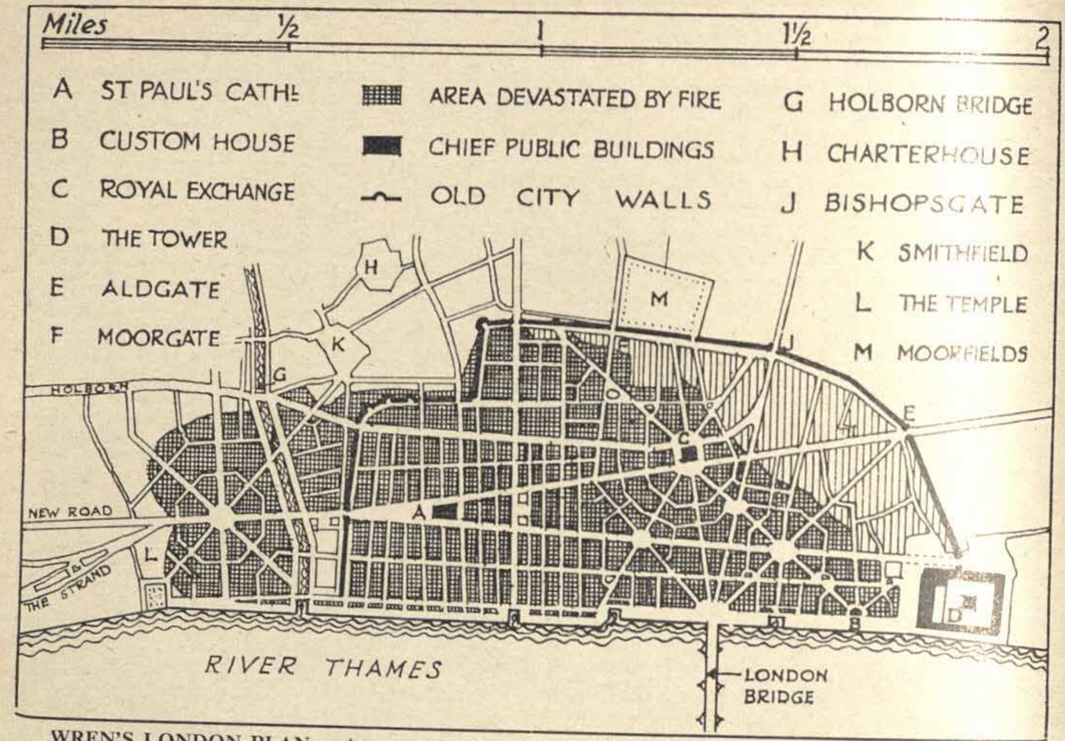
LESSON 15

Town Planning

So far in these Lessons no mention has been made of the grouping of buildings and their relation to each other, except references to Wren's plan for rebuilding London after the Great Fire and Nash's work in the Regency. The term " town planning " seems to have been first used in about 1904. Yet towns were systematically planned by the Egyptians, Babylonians, Greeks, and Romans thousands of years ago. During the Middle Ages it is true this art or science almost fell into disuse, though England does possess a few examples, among them Winchelsea in Sussex, 1287. In Italy and France several towns of the 16th and 17th centuries were properly laid out.

So when Wren and several other competitors prepared their schemes for rebuilding London in 1666, they could have seen some of those towns or illustrations of them. John Evelyn, one of the competitors, had travelled extensively. Wren had visited Paris. Evelyn had certainly seen the model town of Richelieu in France, laid out in 1631–38. There had also been a limited amount of orderly planning in outer London, round Covent Garden and in Lincoln's Inn Fields, both designed by Inigo Jones.

The City of London, when it was burnt down in 1666, was, for the most part, a jumble of narrow, tortuous streets within the medieval walls ; though those walls and the main thoroughfares running east–west and north–south still were, and still are, on the exact lines of the chess-board plan of the ancient Roman city. Wren laid it out afresh with straight streets of adequate width, arranged not only with regard for traffic requirements but also with a view to providing a worthy setting for St. Paul's Cathedral, the various rebuilt parish churches, and other important buildings. There was to be a quay along the Thames, and another on either side of the little Fleet River, now hidden in a sewer under New Bridge Street. The plan had its defects ; but, taken as a whole, one must regret that circumstances did



WREN'S LONDON PLAN. An example of large-scale town planning which was nullified by private interests. Approved by Charles II after the Great Fire of 1666, it was passed by Parliament but never realized.

not allow it, or any other of the competition designs, to be carried out.

The obstacles were the huge number of claims for ownership and compensation to be settled in the law courts, involving years of delay ; and the frantic desire of householders and shopkeepers and merchants to get back as soon as possible to their own old sites of home or business. After the City of London was blitzed in the Second World War another opportunity occurred—and people began to realize the nature and magnitude of the difficulties which had prevented an orderly scheme of planning from being carried out in 1666. One may deplore the failure to replan London on that occasion ; yet one cannot ignore the practical obstacles that stood in the way.

18th and 19th Centuries

Between 1666 and the end of the 19th century town planning in Britain was mainly confined to the orderly development of large urban estates by landowners and speculators. Large areas of west and west-central London (e.g. Bloomsbury and Belgravia) were admirably laid out during the 18th and early 19th centuries. John Nash's splendid planning of the streets from the Mall to " the Regent's Park," as well as his design of that beautiful park, have already been mentioned. There was other Regency town planning at Hove, Brighton, Cheltenham, and Weymouth ; there was the work of the Woods at Bath ; and in Edinburgh there was the " New Town." But abreast of all these were the appalling new developments of the industrial towns, not excluding London, where interminable rows of mean and squalid cottages were packed closely together without regard for anything but cheapness of construction. Even in 1941 there were still 71,000 " back-to-back " houses in Leeds ; 60,000 in Sheffield ; 39,000 in Birmingham ; and 30,000 in Bradford.

In the elegant 18th century some regard had been paid to " good manners in architecture " : that is, to harmony between adjoining buildings. But during the 19th century, after the Regency period, this admirable habit seems to have been neglected ; and the motto of every architect and every landowner erecting a building seems to have been : " Each for himself, and never mind the rest of the street." Thus the shopping streets of our great cities (e.g. Oxford Street and the Strand, in London) nearly all present a motley and discordant array of façades of varying heights and varying styles of architecture, mostly erected in the 19th century.

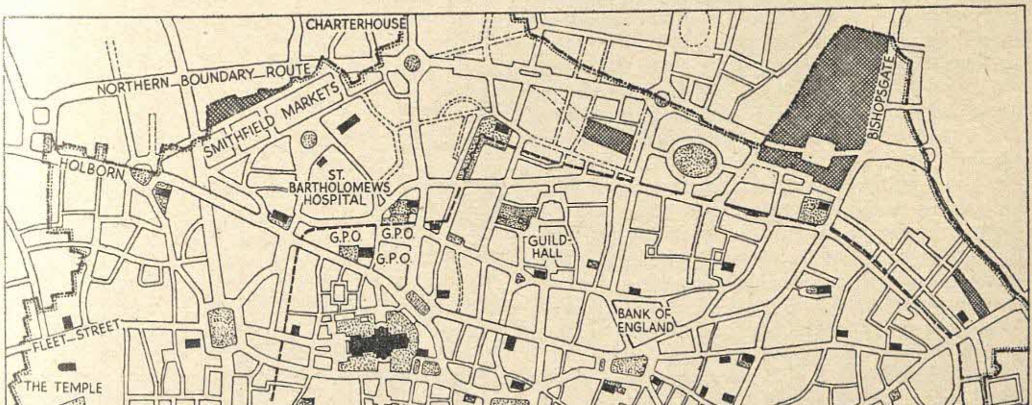
Town planning came to be revived on social and philanthropic rather than on artistic grounds, towards the end of that century. Middlesbrough, Yorks, founded in 1829, and Barrow-in-Furness, Lancs, established rather later, are large towns which were deliberately planned ; but the earliest example of a town laid out with real concern for amenities and for the welfare of its inhabitants appears to have been Saltaire in Yorkshire, founded by a wealthy manufacturer for his workers in 1851. It is a rather grey and gloomy place, and was far surpassed by the model town of Port Sunlight in Cheshire, founded in 1888 by W. H. Lever (afterwards Lord Leverhulme), the famous soap maker. About the same time the firm of Cadbury Brothers established Bournville, near Birmingham.

Both these firms provided not only model factories and attractive houses for their employees, but also excellent public buildings, churches, schools, and playing fields, pleasantly laid out among flower beds and tree-lined avenues—all affording a striking and welcome contrast to the straight monotonous streets still being built in industrial towns to satisfy the minimum requirements of the " model " building by-laws. At Port Sunlight there were only 10 houses to the acre, at Bournville only 7, whereas many older towns contain whole areas of artisan houses planned at 40 or 50 to the acre, which was right up to the maximum allowed under the by-laws.

In 1898 a reporter named Ebenezer Howard, a man without influence or wealth, published a little book titled *To-morrow : a Peaceful Path to Social Reform*, republished in 1902 as *Garden Cities of To-morrow*. He argued that our urban way of life was all wrong, that our cities were far too large and needlessly ugly, that every town-dweller should be able to reach the countryside easily, that it was a waste of time to travel long distances between home and work, and that all these drawbacks could be avoided. He proposed, instead, a new sort of town, combining the advantages of urban and rural life, having a population of about 30,000, occupying about 1,000 acres, and surrounded by an " agricultural belt " of about 5,000 acres. It was to have a public park, a central group of civic buildings, and a definite area for factories providing sufficient work for the citizens and thus avoiding the long journey daily from home to some other town. In fact, it was to be a self-contained community, self-supporting and self-governed. He considered that a population of 30,000 was just large enough to carry these responsibilities.

Garden Cities

In 1899 he founded the Garden City Association, with the result that the first garden city



PLAN FOR BOMBED LONDON. This shows the principal recommendations of the 1947 scheme, by Charles Holden and William Holford, for the replanning of the City of London after the Second World War. It included the making of important new streets, a new Blackfriars bridge, and the elimination of certain railway stations. Compare this with the plan prepared by Wren nearly three centuries ago.

was established in 1903 on a site of nearly 400 acres at Letchworth in Hertfordshire. It grew slowly, but proved a successful venture ; and he took a leading part in founding the second garden city at Welwyn, also in Hertfordshire, in 1919. Both towns have managed to attract a fair amount of industry, and neither has become a mere dormitory for people working in London, though Welwyn is only 20 miles away. Of the two, Welwyn is the better planned, as a result of experience gained at Letchworth.

Garden Suburbs and Housing Schemes

Soon after Letchworth had been started, its designer, Mr. (afterwards Sir) Raymond Unwin was commissioned in 1907 to plan a " garden suburb " at Hampstead on similar lines, but with no pretence that it would form a self-supporting and self-governing community (i.e. a " town "). It was designed to house people of all (or nearly all) social classes, and that was an innovation. When the London County Council established its enormous new town or suburb at Dagenham in Essex in 1921, to re-house its citizens displaced from East End slums, Dagenham was frankly envisaged as a one-class dormitory, so that little provision was made for local industry, its inhabitants being expected to continue working in London and to journey there day by day. There was also, at first, a shortage of churches, shops, etc.

Municipal housing schemes planned outside all the principal towns in England between the two world wars tended to err in the same direction, and provided mainly semi-detached houses or houses in small groups, all with nearly uniform accommodation. Though well designed for the most part, and often attractively disposed over the site, they occupied a vast area of what had been agricultural land, thus spreading the towns into the country and increasing the time taken in journeying to work. The latest tendency, in order to avoid this mistake, is towards more compact planning, with houses in terraces rather than semi-detached, combined with a certain number of flats.

Both Letchworth and Welwyn had been established as " satellite towns " : that is, self-governing communities large enough to provide most urban amenities, including a library, a public hall, a secondary and perhaps a technical school ; but dependent upon some accessible larger town—London in each case—for higher education, theatres, art galleries, and various other facilities which only a large city can maintain. Most of the " New Towns " which have been started in many parts of the country since the Second World War can be regarded as satellites, but some are almost out of reach of any large city. All are intended to be self-contained up to a point, with sufficient local industry within their own boundaries to ensure employment. The problem, therefore, is to attract manufacturers as well as work-people to move out of the overcrowded cities into these " New Towns," in the planning of which the mistakes made earlier in the century elsewhere are being avoided.

Town planning is now an important activity, carried out by experts and regulated by Acts of Parliament. It includes country planning as well as urban development, and it affects many matters besides housing. The scheme submitted for the replanning of the City of London after the Second World War, though not closely resembling that prepared by Wren nearly three centuries ago, proves that the capital of the British Commonwealth could be made much more beautiful and efficient than it is to-day.

BOOK LIST

The Pleasures of Architecture, A. and C. Williams-Ellis (Cape) ; *Architecture Explained*, Sir Howard Robertson (Benn); *Architecture*, M. S. Briggs (H.U.L.); *A History of Architecture on the Comparative Method*, Sir Banister Fletcher (Batsford) ; *A Short Critical History of Architecture*, H. H. Statham (Batsford) ; *The Architecture of Ancient Greece*, W. J. Anderson and W. B. Dinsmoor (Batsford) ; *The Architecture of Ancient Rome*, W. J. Anderson and T. Ashby (Batsford) ; *Greek and Roman Architecture*, D. S. Robertson (C.U.P.) ; *Gothic Architecture in England*, F. Bond (Batsford) ; *Architecture of the Renaissance in Italy*, W. J. Anderson and A. Stratton (Batsford) ; *Renaissance Architecture in England*, Sir R. Blomfield (Bell) ; *Wren the Incomparable*, M. S. Briggs (Allen and Unwin) ; *The Evolution of the English House*, S. O. Addy and J. Summerson (Allen and Unwin) ; *The Growth of the English House*, J. A. Gotch (Batsford) ; *Modern Architecture*, J. M. Richards (Penguin) ; *A Key to Modern Architecture*, F. R. S. Yorke and C. Penn (Blackie) ; *The Modern House in England*, F. R. S. Yorke (Architectural Press) ; *Building Today*, M. S. Briggs (O.U.P.) ; *Town and Country Planning*, Sir P. Abercrombie (H.U.L.) ; *The Development of English Building Construction*, C. F. Innocent (C.U.P.) ; *A Short History of the Building Crafts*, M. S. Briggs (O.U.P.).

BIOLOGY

This Course on Biology, or the Science of Life, gives a short survey of living organisms, both vegetable and animal. It includes an account of Evolution, and of the various theories of inheritance and natural selection enunciated by great biologists such as Lamarck, Darwin, and Mendel, and finally touches on economic factors resulting from the practice of what is termed Applied Biology.

By grasping the principles laid down in these Lessons the reader will be better equipped to understand their elaboration in three complementary Courses : BOTANY, *in Volume 3, which comprises an outline of plant life ;* PHYSIOLOGY, *in Volume 2, a study of the human body ; and* ZOOLOGY, *in Volume 4, where an account is given of the animal world.*

20 LESSONS

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LESSON 1

Some Properties of Living Matter

BIOLOGY is the science of life, the study of the living things, animals and plants, which make up organic nature. It contributes a large part of the fundamentals of such applied sciences as medicine and agriculture, and is of obvious importance in aiding the better understanding of ourselves.

What is Life ?

At the outset one is confronted with the difficulty of saying exactly what life is. There is no fundamental difference, chemically or physically, between the substances of living and non-living matter. The same elements, such as carbon, oxygen, hydrogen, nitrogen, go to form the structure of both animate and inanimate matter, and these elements combine and separate in accordance with the same chemical laws in both kinds of matter—except that in *protoplasm* (a general term for all living matter) they are combined in a much more subtle and complex manner than that in which non-living matter is built up and collectively have properties not shared by inanimate matter.

Growth and Reproduction

The fact that there is no universally satisfactory definition of life is not of any practical importance, for the investigation of living things can proceed perfectly well without one. The most obvious properties of animate as opposed to inanimate matter are the ability to maintain itself in a " steady state " with regard to the environment, to grow, and to reproduce itself.

From the point of view of the chemist and the physicist, the living body may be regarded as a machine always working to adjust itself to its environment. The chemist tells us that when chemical combination takes place between two elements, such as carbon and oxygen, energy in the form of heat is given out ; this process is familiar in connexion with the combustion of coal, which sets free the necessary energy, in the form of heat, to propel a steam-engine.

Energy Transference

In living processes, energy transferences similar to combustion occur, though at much lower temperatures and by a series of many very small steps instead of a few large ones ; such small changes, collectively making large ones, are characteristic of living systems. Another characteristic of living matter is the presence of *proteins*, which are complex substances, of large molecular size, built out of some 20 *amino-acids* in various combinations. *Protoplasm* is a term used in the last century by T. H. Huxley to describe the basic substance of all living matter : it is a convenient general term, but not a simple substance. Protoplasm consists of proteins and other organic compounds, and has a complex organization and structure, containing various inclusions, granules, and vacuoles, which provide a large internal surface, at which it is thought many of the vital processes take place.

Analysis of Protoplasm

Protoplasm can be analysed chemically, though to do so destroys the complex organization to which it owes its peculiar properties. The eggs of such marine animals as sea-urchins are commonly used to provide material for analysis, as they are easily available and comparatively homogeneous. Such an analysis reveals that some 78 per cent. of the protoplasm is water, some 16 per cent. is protein, the remaining substances being fats (or fat derivatives), carbohydrates, and mineral ash. Plant protoplasm will usually contain less protein and more carbohydrate ; the water content is very variable, being higher in active than in inactive protoplasm, therefore high in growing tissues.

Thirty Constituent Elements

Carrying the analysis further and expressing it in terms of elements, it is found that some 30 elements are present. Those in greatest quantity are carbon, hydrogen, oxygen, and nitrogen, which are all constituents of proteins, as are sulphur and phosphorus. Carbon, hydrogen, and oxygen also make up the fats and carbohydrates. Nearly always potassium, sodium, calcium, magnesium, and chlorine are also important, as are iron and copper, which are constituents of important pigments in both animals and plants. Other elements such as zinc are present in very small amounts, though not less important functionally for that.

Protoplasm usually acts as a watery fluid, but as many of its constituents are of a very large molecular size, or are aggregated into particles, it is a *colloid* solution, not an ordinary, or crystalline, solution. The viscosity of such a solution may vary widely, between a fluid *sol* state and a non-flowing *gel* state.

Enzymes as Catalysts

The chemical reactions occurring in living protoplasm are carried out with the aid of *enzymes*, specific protein substances which act as *catalysts*. A catalyst is a substance which facilitates or speeds up a chemical reaction without itself being used up. The more familiar enzymes are those which act outside the cells which produced them, as in the breakdown of food substances during digestion ; but it is safe to say that enzymes of some sort are concerned with all the processes going on within cells as well.

Optimum Temperature

As the rate of chemical reactions increases with a rise in temperature, so physiological processes, which are chemical in nature, will be speeded up as the temperature rises. Proteins, however, can be irreversibly altered by heat ; that is, they coagulate, just as white of egg, which is a protein, coagulates when cooked. Enzymes are proteins, and will be damaged or destroyed by too high a temperature. Accordingly, a physiological reaction, involving enzymes, will proceed more rapidly with rise in temperature, up to a point at which damage to the enzyme begins to interfere with the increased velocity of the reaction due to the high temperature. At higher temperatures, the rate falls off rapidly and the reaction ceases altogether. The " optimum temperature," at which reactions catalysed by enzymes proceed most rapidly, is usually somewhere between 35 and 45 degrees C. ; the actual temperature will depend on the particular systems concerned.

Lower Temperature Limit

Life is confined to a particular range of temperatures, though any one type of animal or plant has a much more restricted range than the overall extent. At low temperatures, physiological reactions may proceed so slowly that, effectively, they stop. This may cause death, though in some cases it may lead only to a suspension of life, which can later be resumed. The formation of ice in animal or plant tissues will obviously damage them. The temperature tolerance of different types of organism varies widely, a fact familiar to any gardener, who knows that some plants are " hardy " and others not.

Upper Temperature Limit

The upper temperature limit also varies : many British marine animals die if the temperature of the sea reaches 25 degrees C. (the annual temperature variation in the English Channel is from 7 degrees to 15 degrees C.). Some insects can survive, in deserts, at a temperature of 50 degrees C., though the internal temperature of their bodies may not be quite as high as this. Some Protozoa are found in hot springs at a temperature of 54 degrees C., and among the plants, certain Algae can live at temperatures of 60 degrees C. or even 80 degrees C., though this is quite exceptional. The causes of death in hot conditions vary widely, but if one vital enzyme is knocked out by the high temperature this may upset the whole system, even if other parts of it are not directly affected.

The temperature of the bodies of most animals, and of plants, will approximate to that of the environment, though they may be a little cooler if evaporation of water is taking place. The birds and mammals are " warm-blooded," that is, they are able to maintain their body temperatures at a constant level, which is independent of that of the environment. This temperature will be the optimum temperature for the particular enzyme-systems of the mammal or bird concerned. The body temperature of mammals will be somewhere between 35 degrees and 40 degrees C., that of birds usually higher, up to 44 degrees C.

Temperature Control

Man has the most perfect control of temperature, but even then there is a daily variation according to activity, and some individual variation. Average figures are 37 degrees C., or something over 98 degrees F. Many mammals have a much less perfect control of temperature, and can stand considerable variation ; bats, in particular, cannot maintain their warmth when at rest, and have to do warming-up exercises before they can fly.

The mechanism of temperature control is essentially similar in mammals and birds. Heat is generated during muscular activity; but instead of being lost as it is in cold-blooded animals, it is conserved by the insulating layer of air held in the fur or feathers. Cooling is due to radiation from exposed surfaces or evaporation of water from the lungs and sometimes from the skin ; not all mammals sweat.

Adaptation to Environment

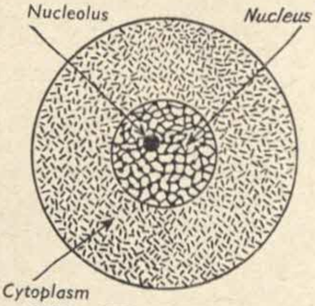
The physiological processes of an animal will be keyed to the temperature at which it normally lives ; this will affect, for instance, the melting point of the storage fats of the body. In the kitchen, a herring is very oily while mutton fat (before subjection to heat) is solid, but when the herring was in the sea and the sheep was alive there would have been less difference in the consistency of their fats.

These examples are given to show that animals, and plants, are adapted to their environments in physiological ways just as surely as in morphological ways, a fact sometimes forgotten, because the latter are much easier to observe. Some of the theories which have been put forward to account for the variety of life on the earth, and to explain how particular forms have arisen, are examined in later pages. Apart from their diversity, living things have also much in common ; some of these common characteristics will be considered first.

LESSON 2

Cells and Cell Division

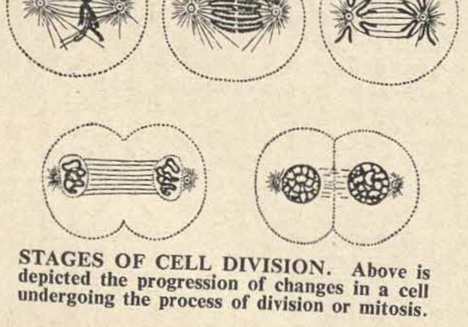
Animal and plant bodies are divided into *cells* (though some consist of only one cell). Each cell is composed of a *nucleus*, or central body, enclosed in a membrane, the whole being surrounded by the *cytoplasm*, again enclosed by a fine membrane and, in plants, by a tough cell wall.



CELL STRUCTURE. A cell is a body composed of a nucleus enclosed in a membrane, the whole surrounded by the cytoplasm.

The fertilized egg from which most plant and animal bodies arise is a single cell. A new body is formed by the dividing of the original cell first into two, then again into four, and so on, until there is a mass of cells, which later differentiate and go to form, some the muscle, some the skin, some the brain, etc., of the new embryonic body, or the various tissues of a seed and a plant. This process of cell division, or *mitosis*, as it is called, continues throughout life, although at a slower rate than at first, and in the adult is confined to certain regions: thus, when one cuts one's chin in shaving it is only the cells in the lower layer of the skin which divide to form new cells to heal the wound. The cells in the upper layer of the skin have lost this power of mitosis, and are short-lived, rapidly becoming more or less horny and being discarded on reaching the surface.

The majority of the body tissues are thus renewed through life by the mitotic activity of some unspecialised cell-group, since a high degree of specialisation, such as is attained by the nerve-cells, is accompanied by the loss of the power of self-multiplication. When a typical animal cell is about to divide, two centres of attraction make their appearance near, but usually outside, the nucleus; and delicate threads of the cytoplasm become radially arranged around these centres to form stars or asters. The rays of the asters stretch out towards each other and finally join up, forming a spindle of threads between the two asters.



STAGES OF CELL DIVISION. Above is depicted the progression of changes in a cell undergoing the process of division or mitosis.

Meanwhile remarkable activity begins inside the nucleus. A long coiled thread appears, which breaks up into a number of short lengths known as *chromosomes*, the actual number of chromosomes being constant for each species of plant or animal. The chromosomes arrange themselves across the spindle between the asters and then split longitudinally, forming a double number of chromosomes—which, however, soon separate into two equal groups, one of which moves towards each centrosome or aster, so that each group of chromosomes contains one of the two halves of each parent chromosome. Having reached the opposite poles of the spindle, the two groups of daughter chromosomes form there the foundations of two new nuclei.

Meanwhile the cytoplasm, which constituted the original cell-body, has also divided into two parts in a plane which passes through the middle of the nuclear spindle and at right angles to its length. In animal cells this division begins as a constriction which starts from the outside, and in plant cells the division is effected by the deposition of a cell plate in the equator of the nuclear spindle. During this process of mitosis a bubbling activity—something like the appearance of boiling pitch—is noticed over the whole surface of the dividing cell; but when the division is complete the new cells relapse into a longer or shorter period of quiescence accompanied by growth. It is important to note that in this process of mitosis each chromosome splits longitudinally; for, as is explained later, each chromosome is composed of a string of little packets of discrete chemicals. By splitting longitudinally instead of transversely, each new cell is assured of its proper quota of each kind of these packets.

By this process of cell division unbroken continuity has been established in the chain of living things from the earliest appearance of organisms to the present day. Every cell is the descendant of pre-existing cells ; as to how the first cells appeared, it is possible only to speculate.

The existence of living organisms must have been preceded by the existence of the large organic molecules of which protoplasm is formed. Though at present the spontaneous generation of organisms never takes place, it does not follow that this could never have happened in early stages of the earth's history when conditions were very different from now.

For instance, the presence of oxygen in the atmosphere almost certainly depends on the activities of green plants, which in light give out oxygen. The presence of oxygen in the upper atmosphere cuts out much of the short-wave (ultra-violet) solar radiation ; before the green plants developed, therefore, the surface of the earth would have been exposed to radiation from the sun with a greater ultra-violet component than it is now. Ultra-violet radiation is capable of interfering with some chemical reactions (indeed, it is dangerous to living tissues) but it is just this sort of factor which might have brought about the formation of protein molecules and so made possible the development of organisms. Such speculations would of course carry more weight if they had been properly investigated in laboratory experiments which reproduce the postulated conditions ; though this has not yet been done, there is no reason in principle why it should not be done.

A microbe, or bacterium, is a microscopic speck of protoplasm which can multiply itself by fission at an enormous rate. There is often no clearly defined nucleus in a bacterial cell, but the proteins characteristic of the nuclei of other organisms are nevertheless present. An individual bacterium may have an active life of about twenty minutes in favourable surroundings, but in unfavourable conditions it turns itself into a resistant tough-walled spore that has been known to survive in the very low temperature of liquid air for six months, and at the other extreme in a temperature of 120 degrees Centigrade. Although they are so small—from a twenty-five thousandth to a fifty-thousandth of an inch across—bacteria play an important part in our lives. They are responsible for such diseases as cholera, typhoid, tuberculosis, etc. But their beneficent influence is such that life would be impossible without them. It is bacteria that seize the nitrogen from the air and turn it into substances suitable for absorption by plants from the soil.

The flavour of butter, the distinctive flavours of wine, the special properties of different cheeses, are all due to the activities of different kinds of bacteria ; more important still, bacteria are essentially the agents of putrefaction and decay. Not only are the dead bodies of higher organisms cleared away by putrefaction, but the bacteria break down the complex mass of chemicals that make up the living body into simpler forms—carbon and carbonates, nitrogen and nitrates—that can again be used by growing plants. Thus the bacteria are nature's dust destructor and sewage farm combined, turning waste matter into useful, life-sustaining material.

The ordinary microscope can be made to reveal objects of about one hundred thousandth of an inch across. With the use of ultra-violet light, photographs can be taken of objects even smaller than this. Using a beam of electrons instead of a beam of light, structures very much smaller still can be detected, perhaps a hundred times smaller than can be seen with visible light. It is known that there are living things smaller even than the bacteria. They are so small that they will pass through the pores of a porcelain filter, although this filter will hold anything down to one hundred thousandth of an inch in size, and these ultra-microscopic organisms are accordingly called filter passers ; they are also called *viruses*. Virus particles can be detected with the electron microscope, and they appear to consist of nucleo-protein. All viruses depend for their existence on other organisms ; they may occur in animals or plants ; some are responsible for the mottled and streaked colours in tulips.

LESSON 3

Single-Celled Animals and Plants

THE smallest animals and plants have bodies consisting of only one cell, or alternatively may be regarded as being non-cellular. Zoologists and botanists classify such organisms in the Protozoa and Algae respectively ; the Algae include seaweeds as well as small unicellular plants, and the Protozoa are usually taken to include these unicellular plants, as well as other forms which are true unicellular animals. There is, in fact, no clear distinction between plants and animals at this level. We can broadly distinguish the higher plants from the higher animals by the following :

(a) Plants are stationary ; animals have means of locomotion.

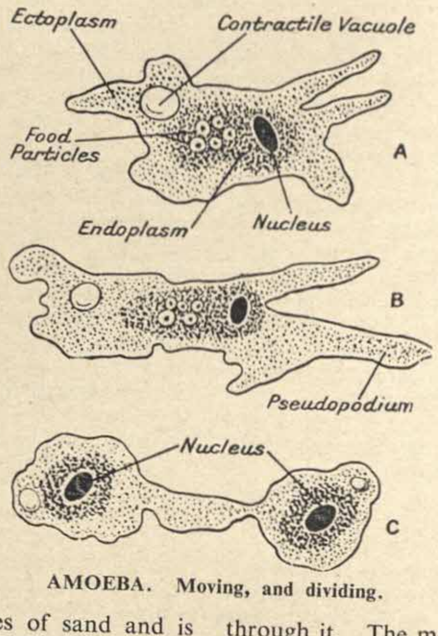
(b) Plants do not possess the complex digestive, nervous, and sensory organs of the animal world.

(c) Plants obtain energy by means of chlorophyll direct from the sun's rays, and use this to make their food ; animals must obtain their food from the bodies of other organisms.

Chlorophyll is a green pigment that is found only in plants, and by its aid the plant can build up water and carbon dioxide into carbohydrates, using solar energy to do so.

In low forms of life some of these distinctions disappear. Thus many small crude forms of plants move about, and even that great characteristic of plant life, the possession of chlorophyll, disappears in the case of fungi and some unicellular organisms which appear otherwise to be plants. These considerations all point to the fact that both animals and vegetables evolved from common ancestors, which were neither distinctly animal nor vegetable but had the characteristics of both.

An example of a unicellular animal is *Amoeba*, a protozoon described more fully in the Course on Zoology. It is illustrated here. There is a nucleus, and the cytoplasm contains various vacuoles and inclusions. The *contractile vacuole* is concerned with regulating the water-content of the body. The amoeba moves by putting out *pseudopodia*, and catches its food (smaller protozoons, or bacteria) by surrounding the prey with cup-like pseudopodia, and incorporating it into the body in a *food vacuole*, where it is digested. There is then a digestive system in amoeba, even though there are not specialised organs as there are in larger animals.



AMOEBA. Moving, and dividing.

Similarly, as far as is known, an amoeba has no discernible nervous system, such as the higher animals possess; but this tiny protoplasmic body avoids particles of sand and is able to select food particles from among them, the inference being that the protoplasm as a whole is sensitive to stimuli.

After the food is digested, it is taken into the protoplasm and there further broken down to release the energy needed for the activities of the amoeba. This breakdown of food substances in the protoplasm is known as *respiration* ; most animals require oxygen for their respiratory processes. A cycle of chemical changes takes place in the protoplasm during which oxygen is used up and the food substances are broken down to carbon dioxide and water. Energy is released during this process, some of which appears as heat ; the rest is used up in the various physiological processes of the amoeba. Respiration is a process similar to combustion, but it takes place at much lower temperatures, and by a series of small steps ; the chemical reactions are catalysed by enzymes, and various substances in the protoplasm are involved in the breakdown and recombination of elements in the various molecules.

If food is plentiful the amoeba grows, but there is a limit to the size to which it can grow. It behaves at this climax like all living cells. It divides and becomes two amoeba instead of one overgrown one (*see* C in diagram).

There must now, for the sake of contrast, be considered an organism in the vegetable world which is on the same lowly plane in the vegetable kingdom as the amoeba occupies in the animal kingdom. Such a plant is *Sphaerella.* It occurs in stagnant pools. Though so small that it is individually invisible to the naked eye, it may be present in such numbers as to colour the water. Sometimes *Sphaerella* develops a red pigment as well as its normal green, especially when passing into a resting phase. Each individual is a round cell with one nucleus, as in the amoeba ; but, unlike the latter, it is surrounded by a cell wall composed of cellulose. This cell wall is a distinctive mark of a vegetable, as is also the green colouring pigment called chlorophyll.

Instead of pushing out projections of jelly, like the amoeba, these tiny plants are furnished with two thin threads of protoplasm which lash about in the water and propel—or rather pull, for they are carried in front—their owner through it. The movements of these whip-like flagella are due to the protoplasm's power of contraction. The plant obtains the energy needed to maintain itself, and to build up new protoplasm, from the breakdown of food substances in respiration, just as an animal does. But where the amoeba must take in food and digest it, *Sphaerella*, being a green plant, can manufacture its own food from sunlight, water, and carbon dioxide. It also needs mineral salts to form proteins. The process of food-building with the aid of light is known as *photosynthesis*, and can be performed only by those plants possessing the green pigment *chlorophyll.* Further details are given in the next Lesson.

Between these specimens of elementary life there are many points of resemblance, and one important distinction—their manner of feeding. The animal amoeba is able to live only on other organisms ; the vegetable *Sphaerella*, owing to its possession of the green pigment chlorophyll, can, by action of the sun's rays, absorb its food in the raw, so to speak.

This is the fundamental difference between animals and plants—a difference of biochemical aptitude. Animals are obliged to hunt for food, because they cannot make it for themselves. Probably the loss of that faculty followed the acquirement of an ability to take in organic matter which had already been synthesised elsewhere ; even plants which are not green, such as the fungi, are not able to utilise radiant energy, and must absorb various organic materials. Movement, which does occur in some plants, may originally have been a device for reaching a new environment for the sake of fresh mineral salts, and so on. Larger plants produce a similar effect by increasing their extent, as by forming leaves and roots.

Animals used their motivity, and developed sensitivity, to aid the hunt for food ; this was the spur for the differentiation of all the multitudinous animal types, including ourselves, for the development of intelligence in man can also be regarded as an adaptive animal character, which has in fact made man the dominant animal that he is. Perhaps he will be able to re-learn how to synthesise food, but at present he is dependent on the green plants for doing so. In any case the plants would be more economical food producers, and there is no reason to suppose that laboratory synthesis could replace agriculture.

The term *symbiosis* is used to describe a situation in which two organisms, of different species, live together to their mutual benefit ; single-celled plants often form one of the partners. For instance, the lichens are compound plants formed of algal cells embedded in a weft of fungal threads ; the algae gain protection, and probably a supply of water, while the fungus profits from the food substances manufactured by the green algal cells. Similar unicellular algae may live within animals ; the green *Hydra* owes its colour to such guests, which also occur in many sea-anemones and in most corals. Another example of animal-plant symbiosis is that of the little flatworm *Convoluta*, which lives on the sea shore in Brittany. When the tide is up it buries itself in the sand, but when the tide falls the worms ascend to the surface of the wet sand, in order to expose the algal cells in their bodies to light. The algae are protected and also obtain carbon dioxide and salts from the worm, while the worm gets food from the algae, probably by digesting a certain proportion of the algal cells. Instances are also known in which different animals live in close association, but this is usually spoken of as *commensalism*.

LESSON 4

Mechanism of Plant Life

PLANTS, as pointed out in the previous Lesson, are the universal food providers, and they alone are able, while manufacturing food for themselves and the animal world, to use for this purpose the energy supplied by the rays of the sun.

Like animals, plants contain carbohydrates and proteins ; the proteins of plants are simpler than those of animals ; a plant is able to manufacture both carbohydrates and protein for itself from the raw material. It may be well to remind the student that carbohydrates are compounds of carbon, hydrogen, and oxygen, and that proteins are various complex compounds of nitrogen, carbon, hydrogen, oxygen, sulphur, phosphorus, and iron. In the ash of burnt plants there always appear, in addition to the above minerals, traces of calcium, magnesium, and potassium, also essential to the plant's growth.

The basic food substances manufactured during photosynthesis are sugars such as glucose ; they are formed from carbon dioxide and water in a process which apparently consists of two stages. First, the action of light on the chloroplasts (the chlorophyll-containing bodies in the cells) splits water into its components, hydrogen and oxygen. The oxygen is given off, but the hydrogen is used in the second stage, being combined with carbon dioxide to form the simple sugars such as glucose. Some glucose can be used directly in respiration, being broken down again, with the release of energy, to carbon dioxide and water, oxygen being used up.

As far as the end-products are concerned, then, photosynthesis is the reverse of respiration, though this is not true of the intermediate steps. The energy of respiration is needed to synthesise more complex carbohydrates from the simple sugars formed in photosynthesis, such as other sugars, which are transported to all parts of the plant ; or starch, which is stored, and also in the synthesis of amino-acids and proteins, and other substances. For protein synthesis, nitrogen is required, and this and other nutritive substances needed by the plant are absorbed by the roots. None of the nutritive substances of plants is taken in solid form ; they are either gaseous or in solution in water.

If photosynthesis is proceeding actively, as in a green shoot in bright light at a suitable temperature, more oxygen is given off than is used up in respiration, and the carbon dioxide resulting from respiration will all be used up in photosynthesis ; such a shoot will contribute oxygen to the atmosphere. The parts of plants which are not green, or the green parts in the dark, will use up oxygen and give off carbon dioxide just as animals do. There will also be a constant loss of water vapour, by evaporation from the intercellular spaces of terrestrial plants; this has to be made up by the water absorption of the roots, otherwise the plant wilts.

For details of the economy of plant bodies, for instance as to how water and nutritive fluids are transported from place to place, reference should be made to the Course on Botany. Here it is only intended to point out that plants elaborate the material of their bodies from simple substances which they take in as gases or in solution ; whereas most animals obtain food in solid form and have to break it down, by digestion, before it can be used for respiration or body-building. The processes of respiration and, for instance, protein synthesis may be essentially similar in plants and animals, though not similar in detail.

Anaerobic Respiration

Most animals will die if deprived of oxygen, and while most plants also use oxygen in respiration and indeed will not grow without it, plant tissues are also capable of respiring without the intervention of oxygen ; this is known as *anaerobic* respiration. The anaerobic respiration of sugars results in the production of alcohol, carbon dioxide, and energy, but a smaller proportion of energy than would be produced by the *aerobic* respiration of the same quantity of sugar (that is, its respiration with oxygen). Yeasts, which are plants, respiring anaerobically, are responsible for the production of alcohol in the fermentation processes going on during the making of wine or beer.

Though animals are dependent on plants for their food, the benefit is not all one way, for the presence of animal life means there is a much quicker turnover of nutritive substances. Bacteria break down the faeces of animals, or their dead bodies, and so enrich the soil to the benefit of plants. Animal respiration ensures that there is plenty of carbon dioxide to be used in photosynthesis. Further, some plants make use of animals in their reproductive processes, or in the distribution of seeds.

In a climate such as Britain's, some plants have learned to "close down" their food factories at the approach of winter. A little layer of cork cells is formed in the leaf stem. The last supply of food material has ascended in the sap stream ; some of this material has been stored in the seeds ; some has gone to form new growth ; but the supply of nourishment to the leaf is now shut off by this ring of cells. The leaves lose their green chlorophyll and display those beautiful autumn tints which (in this connexion) are a sign of death. The leaf stem finally fractures at the point where the cork cells formed, and the leaf flutters to the ground.

The student should study exceptions to the green plant's routine of food making: e.g. the growth of parasites, such as the mistletoe, which gets its food ready-made from the oak branch ; and he should read Darwin's book on the growth of orchids. The yeasts and moulds have also their own ways of getting a living, and the legumes (peas, beans, and laburnums) seek the aid of bacteria to collect nitrogen for them from the air.

LESSON 5

Sexual and Asexual Reproduction

Lesson 3 included a description of *Sphaerella*, but did not include an account of the reproductive activities of the plant. As with amoeba, reproduction is carried on by the fission of the original cell ; but instead of splitting into new individuals *Sphaerella* usually splits into four. At times, however, the mother cell will split into as many as 32 or 64 smaller individuals, which move about by means of their *flagella* (whip-like threads), and presently come together in pairs, fusing to form one larger cell with four flagella but a single nucleus. These four whip-like threads are lost ; and, after a resting period, the new individual which has been formed by conjugation returns to the ordinary method of reproduction, and divides into the usual four.

The process of conjugation and complete fusion of two individuals is a sexual phenomenon, though there is no apparent difference between the two individuals which join. Nevertheless, they may be called *gametes* and the resulting individual a *zygote*. In most animals and plants (even in the unicellular ones sometimes) one gamete (the male) is very much smaller than the other (the female).

Fission and Budding

Any form of reproduction which does not involve the fusion of gametes is called *asexual*. The fission of amoeba, or of *Sphaerella*, is a type of asexual reproduction. Some multicellular animals may also reproduce asexually by splitting off part of their bodies, though it is more usual to grow a *bud* in animals. Animals able to reproduce asexually by budding include most of the coelenterates, many flatworms, and some marine ringed worms; also the sea-squirts.

It is a more familiar fact that many plants can reproduce asexually, by suckers and so on.

A typical form of sexual reproduction occurs in the ciliate protozoa such as *Paramoecium*. The process is spoken of as *conjugation*, and it involves the exchange of nuclear material between two individuals, without any formation of gametes. Details are given in the Course on Zoology.

Another anomalous type of reproduction is *parthenogenesis*, or virgin birth. Here the new individual is developed from an egg cell, or female gamete, but without the intervention of a male gamete. Parthenogenesis occurs in the life histories of insects such as aphids, and of crustaceans such as water-fleas.

Meiosis (Reduction Division)

It was previously mentioned that the number of chromosomes in a cell nucleus is constant in any one species of animal or plant, the number being maintained in all cells by the process of cell-division, *mitosis*. During sexual reproduction, since the nucleus of the male gamete fuses with the nucleus of the female gamete, the resulting fertilized egg cell, or zygote, would contain a double number of chromosomes if the gametes themselves contained a complete number, and the next generation of gametes would produce a quadruple zygote, and so on indefinitely. But mitosis does not take place in the formation of gametic cells, and, in consequence, they do not possess the same number of chromosomes as the somatic cells. Instead, as the gametes are being formed, the chromosomes line up in pairs across the spindle, and then, before the cell divides, one whole chromosome of each pair goes to one pole and the other chromosome to the other pole. This nuclear division is always followed by a second formation of nuclear spindles, at right-angles to the plane of the original one ; the chromosomes then divide and their halves move to opposite poles of the secondary spindles. When the nuclei are reconstituted, there are four, each with half the original number of chromosomes.

Haploid and Diploid Cells

These are the nuclei of the gametes, in animals, though in plants other stages intervene between the reduction division and the final formation of the cells which fuse to form the zygote. Thus, if the original number of chromosomes was six, only three would be found in the gametes. (Compare this reduction division, or *meiosis* as it is called, with the mitotic division shown in the illustration depicting stages of cell division.) The consequence is that when the male gamete meets and fuses with the female gamete, the resulting zygote will contain the double number of chromosomes once more. Cells possessing a single set of chromosomes are called *haploid* cells ; when the double set of chromosomes is restored, they are called *diploid*.

Plants show an *alternation of generations*, one diploid, the other haploid, though in the seed-bearing plants the latter is inconspicuous. In animals, though in males all four nuclei resulting from reduction division may form gametic nuclei, in females only one of them becomes the actual nucleus of an egg cell. The other three nuclei are those of the *polar bodies*. The egg-cell is usually shed from the ovary when only the first of the two nuclear divisions of meiosis has taken place. One of the resulting nuclei is extruded from the egg cell, with only a little cytoplasm, as the *first polar body*. Before anything else happens, the male gamete, or spermatozoon, enters the egg cell, losing its tail as it does so. This is the signal for the completion of the female reduction division. The egg cell nucleus divides again, one of the daughter nuclei being extruded, again with only a little cytoplasm, as the second polar body, while the other daughter nucleus is the gametic nucleus and fuses with the nucleus of the spermatozoon. The first polar body may also divide again, to complete the tale of four nuclei.

In parthenogenetic animals such as aphids and waterfleas, though there is an alternation of sexual and asexual generations, they are both diploid, for the parthenogenetic eggs do not undergo a reduction division.

Reproduction of Bees

One further anomaly is that in the Hymenoptera, that order of insects including bees, ants, and wasps, the males are haploid, the females diploid. A queen bee, then, lays fertilized eggs which develop either into workers or queens, depending on the food they receive, and a smaller number of unfertilized eggs which develop into males, the drones. The determination of sex in other animals is discussed later.

The bodies of animals and plants are formed by the successive cell divisions of one cell and its offspring, and in their development the cells assume different types for different functions. In the cell society called a higher plant or animal there occurs a division of labour analogous to that in human societies and in the societies of ants and bees. It may be asked how the special powers and forms of all the myriad types of cells in our bodies are predetermined and contained in the single cell, less than 1/100th of an inch across, which was the common ancestor of them all. There is a partial answer, discussed later, but the exact mechanism is still very obscure. Sexual reproduction has one great advantage over any asexual method : it permits the recombination of hereditary factors derived from different individuals. There is, then, variation within stocks, on which the selective forces of evolution can act.

LESSON 6

Plant Fertilization

THE reproduction of plants is treated in greater detail in the Course on Botany, here only in outline. This process is especially interesting because, since plants are hampered in conjugation by inability to approach each other, they have developed, in the course of evolution, the most amazing devices for overcoming this difficulty—the difficulty, that is, of arranging that the nucleus of a cell in the pollen grain growing on a stationary plant shall meet, and fuse with, the nucleus of a cell in the ovule which is developed in the ovary of another stationary plant growing some distance away.

Reproductive Organs of Plant

Animals may show very complex mating behaviour, to ensure that fertilization takes place, but since they are in any case motile and sensitive the problem is rather different. Most flowering plants, though not all, are bi-sexual and possess, therefore, the organs proper to both sexes. The parts of the plant essential for fertilization are the stamens, anthers (male organs), pistil, and ovules (female organs). The stamens in many flowers are conspicuous spindles, each with a box-like anther at the end, which contains the pollen grains, cells which have arisen by a reduction division. These stamens surround the pistil, which consists of three parts. The lowest is a baglike ovary connected by the middle part (style) to the stigma at the top. The stigma can be recognized by its knob-like, or, in some plants, plate-shaped, tip, which is generally either hairy or sticky. When a pollen grain is ripe, it contains two cells ; the pollen grain, either from the same flower or from some other, falls on the female stigma. As a result, one of these cells (A) pushes out its wall in the form of a tube, which burrows its way down through the stigma and style to the ovary, where it penetrates an ovule.

The ovule is now a mass of cells wrapped up in a seed coat which has grown around them, but which has not quite enclosed them. There is a tiny hole left at the top through which the pollen tube, formed by cell A, enters, and down this tube come the two nuclei (the male gametes) of the other cell (B) in the pollen grains. Within the ovule is a structure, the *embryo sac*, which has developed from one of the four daughter cells of a reduction division. While it grows the embryo sac has only one nucleus, but this later divides into eight, one of which is the egg nucleus. The first male gamete approaches and fuses with the egg nucleus.

The second male gamete from cell B is prevented from joining in this act of fertilization because—and this is an invariable and important rule—as soon as one male gamete has fertilized a cell chemical changes occur in the fertilized cell, or zygote, which make it impossible for another male gamete to enter. Instead, the nucleus of this second male cell fuses with two other embryo sac nuclei and forms a very much larger nucleus, which by mitotic division constitutes the rest of the seed. Cell walls appear round the nuclei of the embryo sac only after these fusions, and some divisions, have occurred. Thus, in a wheat grain the fertilized egg or zygote is only a tiny part ; the rest of the grain (which is called the *endosperm*) formed from the fusing and subsequent division of the three nuclei is a mass of starchy food on which the embryo will live. In a ripe seed the zygote has already developed into an embryo with vestiges of the first leaves and roots. There may be a resting period at this stage.

Flowers and Insects

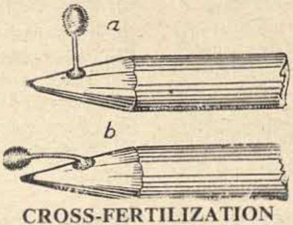
Many plants reproduce themselves by self-fertilization, that is, the pollen from the anther falls on the stigma of the same flower ; but more commonly the flower is so constructed that either this cannot happen or it happens only as a last resort. As Darwin pointed out, nature appears to abhor perpetual self-fertilization. For this reason, in the case of the grasses and numerous other plants, flowers are pushed up above the surrounding foliage in order that the wind, as it carries the clouds of pollen, will be certain to pollinate every flower with pollen from another plant (incidentally inflicting hay fever on some human beings in the process).

Cross-Fertilization

The most wonderful method of cross-fertilization is that carried on by co-operation between plant and insect. The plant advertises its possession of nectar, a sugary liquor attractive to bees, moths, and other insects, by means of its coloured flower petals and by odours which in most cases are pleasant to both insects and mankind. Sometimes, however, the odour, although attractive to insects, is repugnant to man. Some irises, arums, and the marsh calla not only emit the putrid odour of decaying flesh, but in the livid green, brown, and purplish shades of their petals imitate dead flesh, and are thus attractive to the carrion-feeding flies and beetles.

The construction of the flower is often such that only an insect of a certain shape and size, or with a proboscis of the right length, can reach the nectar ; as it does so, some part of the insect's body must brush first against the stigma and later against the stamens. Emerging, the insect takes the pollen from the stamens of one flower and deposits it on the stigma of the next.

The flowers have ingenious arrangements for ensuring that only the right kind of insect will enjoy their nectar. The sweet pea, for example, lightly closes the edges of its two petals and thus prevents all small insects from stealing its nectar. When a heavy bee settles on the flower, its weight levers these petals apart, the bee's long tongue uncurls and sips the nectar, while a tiny " brush " shoots out from the flower and dusts the breast of the bee with pollen. On the bee's visit to the next sweet pea flower, some of this pollen is deposited on the stigma. Bees will also visit flowers for the sake of the pollen, which they collect to use as food ; this will be equally useful to the plant, for relatively few pollen grains need reach other flowers.



CROSS-FERTILIZATION
To make the process clear a pencil is substituted in this diagram for the insect's head : *a*, position of pollinium on leaving the first Orchis mascula ; *b*, same before entering the second orchid (see text).

Adaptation and Co-operation

Some of the most astonishing instances of adaptation for cross-fertilization occur among the orchids. In *Orchis mascula* of the British countryside, for example, when the visiting insect thrusts its head forward to reach the nectar a viscid disc is detached from the flower and adheres to the head of the insect. Standing upright from the disc is a thin stem, which bears a pollen packet on its top. The viscous matter in the disc sets hard, like cement, and the insect withdraws from the flower, bearing on its head an upright pollen-bearing banner, technically known as the *pollinium*. If this were all, nothing would happen, for when the insect visited another flower the pollen packet would merely fit into its former position in the flower. But the viscous disc has contracted, as it dried, during the short flight from flower to flower, and through this contraction the thin stem bends over to the horizontal position, with the result that at the next *Orchis mascula* flower-entry the pollen packet is pushed against the stigma.

The shrub yucca exhibits another instance of co-operation between plant and insect. The whitish flowers are closed during the day, but, as evening approaches, the bell-like blossoms gape wide open and are visited by a species of small white moth—the only insect capable of fertilizing this plant. The female moth visits flower after flower of the yucca, gathering pollen and carefully rolling it up into a pellet as she goes. When the ball of pollen has become about twice or three times the size of her head, she changes the routine. Arriving at the next blossom, she visits the ovary first, plunges her sharp-pointed ovipositor into its soft wall, and deposits eggs near one of the ovules of the flower. She then climbs up to the stigma and thrusts her carefully garnered ball of pollen into one of the clefts on the surface of the stigma. The moth has fertilized the plant not from any altruistic concern for its welfare, but in order that the grubs which will hatch from her eggs in the ovary will presently have fertilized yucca seeds to eat. Over 200 seeds are produced in the ovary, and many will be left for reproduction of the yucca.

Though such mechanisms appear purposive, it is probable that all can be explained as adaptive mechanisms produced by selection. For instance, the colours of flowers are such as will be easily visible to the insects normally fertilizing them (insect vision does not necessarily cover the same range of the spectrum as does our own) ; this can be explained by the fact that insects will tend to visit the more conspicuous flowers, and therefore the plants with conspicuous flowers will produce more descendants than those with less conspicuous flowers. The same argument can be applied to flower odour, and to the less obvious adaptations, though the details may often be obscure.

LESSON 7

Mendel's Work in Biology

So far this Course has been concerned with the study of some of the functions of living organisms both in the plant and the animal world, and the student of biology may now ask how these diverse organisms arose, and how they acquired the complicated mechanisms which enable them to live, obtain food, and reproduce themselves. It is a common belief to-day that all life, complex and varied as it is, arose in the long course of evolution from simpler forms ; but the question of how this complexity and diversity appeared has exercised men's minds for generations past, and the final answer to the question is still a matter of controversy.

One of the smaller categories into which biologists have classified living organisms is termed a species. A species may be defined as " a group of living things of the same structure which breed freely among themselves but do not interbreed freely with members of other groups." Charles Darwin, in England, published his theory of natural selection as a cause of the origin of species in 1859 ; a couple of years before that Gregor Johann Mendel, abbot of the monastery of Brünn, in Silesia, had begun his experimental studies of the effect of heredity in plants and insects.

Mendel had the great garden of the cloister at his disposal, and into it he introduced many new plants in order to study their behaviour. Heredity was his special interest ; he studied the results of mating individuals that were conspicuously different in their personal characteristics. His best known work was on heredity in the edible pea. He observed the facts of heredity in that form of plant during the eight years of his life which really matter for us, and read his now classic paper before the Philosophical Society of Brünn in 1865. At intervals during the next few years further papers of his were read, but very soon after Mendel's appointment as abbot of the monastery his scientific work came to an end.

The Edible Pea as a Study

The all-important paper on the pea was duly published in the journal of the society before which it was read, and copies of it are known to have been sent to the leading scientific societies of the world, in the usual way. But Brünn was not a centre of science, and the transactions of local societies are not always of universal interest. Possibly no one in London read the paper. Even where notable men were approached by Mendel himself they failed to realize the importance of his pioneering work, and took no notice of it, probably because the intellectual atmosphere of the time was unfavourable to the work. After the publication of Darwin's *The Origin of Species* scientists were looking for the variations in stocks on which selection could act. Mendel's experimental results might at first sight appear to show that there was no true variation, only a recombination of invariable characters.

Perhaps that was why Mendel, while still interested in his own work, and writing to other students, did not write to Darwin. All the world heard what happened when another worker wrote to Darwin in 1858 ; Alfred Russel Wallace's paper was at once read, appreciated, and, as soon as possible, given the widest publicity, though its arrival prejudiced Darwin's claim to priority with a theory which he had, in fact, framed long before.

It is recorded that Mendel once remarked that Darwin's theory did not completely account for the facts, but he failed to send a copy of his paper to Darwin at the very time when the scientific world was in a tumult over Darwin's theory. Perhaps Darwin, who realized that the mechanism of heredity was little understood, would have recognized the importance of Mendel's work. Discoveries made " before their time " are apt not to attract attention, or to be ridiculed.

Mendel died in 1884, two years after Darwin's death. His later years were overshadowed by disease and embittered by a long dispute with his government and by the knowledge that his discoveries had failed to attract the appreciation that they deserved. It was not until 1900 that De Vries, Correns, and Bateson drew attention to Mendel's discoveries. Bateson pointed out that here was " the clue to the study of heredity. Whither that clue will lead," he added, " we dare not yet surmise."

Mendel's Technique

Mendel chose garden peas for his experiments because in this species each plant normally fertilizes itself. He removed the stamens and pollen from a flower on a dwarf pea and fertilized the remaining stigma with pollen from a tall variety. He also ensured that this fertilization and no other should take effect, by enclosing the flower in a paper bag.

In the first generation (F_1, let us call it), all the peas were tall. (Popular opinion at that time would have predicted either a blend, that is, a pea midway between the dwarf and tall parents, or a mixture of tall and short peas). When the F_1 peas were either crossed among themselves or self-fertilized, Mendel obtained 25 per cent. short and 75 per cent. tall in the F_2 generation.

Second and Third Generations

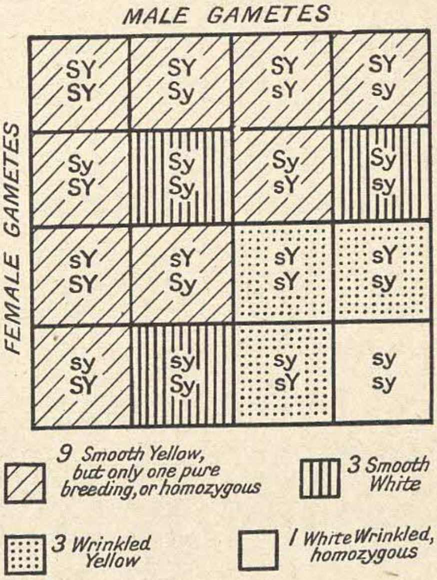
When the F_2 generation was self-fertilized, the 25 per cent. dwarf peas bred true for dwarfness generation after generation, but it was found that the 75 per cent. tall consisted, in fact, of 25 per cent. pure tall which, like the pure dwarf, bred true for tallness generation after generation, and of 50 per cent. impure tall. When self-fertilized, this 50 per cent. of the F_2 generation behaved like the F_1 generation, and bred an F_3 generation consisting of 25 per cent. pure dwarf, 25 per cent. pure tall, and 50 per cent. impure tall, and these continued, if self-fertilized, to breed in the same way. Similar experiments were made using contrasting flower colours, or the colour and shape of the seeds.

Mendel's explanation was that characters such as tallness and shortness existed as independent factors in the marrying cells or gametes. In the pure-breeding tall pea, a male gamete coupled its gene for tallness with the gene for tallness existing in the female gamete, so that we may write the constitution of the resulting impregnated cell as T.T.,—containing, that is to say, a double dose of tallness. Hence future generations from this plant, self-fertilized, can produce nothing but tallness. So, too, with the pure-bred or pure-breeding short plant. We may consider its impregnated germ cell as

S.S., for shortness. But when a T.T. plant mates with an S.S. plant, these factors or genes, being independent, will rearrange themselves according to a simple mathematical law. If we drew two pennies at a time out of a bag on a great number of occasions, we should draw one head and one tail together uppermost twice as often as we drew Head Head or Tail Tail, and the total results would be in the same ratio : 25 per cent. H.H., 50 per cent. H.T., and 25 T.T., which is exactly what Mendel obtained in his F_2 peas. As a result of these experiments, Mendel formulated his first law, that of the "segregation of germinal units, or factors." This law states that " of a pair of contrasted characters, only one can be present in a single gamete."

Dominant and Recessive

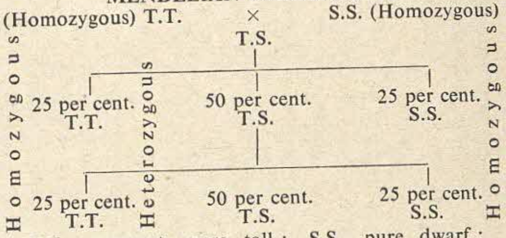
Mendel assumed that one of a pair of two alternative factors such as tallness and shortness was dominant to the other. This means that when the gene for tallness mated the gene for shortness, the resulting impregnated cell, although " mixed " as regards the two characters, showed only tallness because that character masked, or was dominant to, the other, shortness. Shortness is, therefore, called a recessive character, and tallness a dominant. Later workers called alternative factors *allelomorphs*, and the factors themselves *genes*.



To understand why Tall × Short produces Impure Tall, the student should realize that a pure-breeding plant must have a double dose of the character in question (T.T. or S.S., as the case may be). Such plants are termed *homozygous*. But plants that yield offspring some of which have one character and some the other, possess a single dose only of each of the allelomorphs. Such plants are called *heterozygous*, and they would be represented as T.S., if the factors concerned are tallness and shortness. Therefore, Mendel's experiment can be represented as shown in the diagram in the next column.

Since 1900, when Mendel's papers came to light, many breeding experiments with both plants and animals have been carried out, which have amply confirmed the truth first established by him, viz. (a) that simple characters such as tallness and shortness behave as units ; (b) that one of these units is unaffected by its association with another unit in the gamete of the same plant, and is carried on unchanged from generation to generation. Thus, F_1 plants, although tall, contained the dwarf pea gene as was proved in the F_2 generation ; in that generation the allelomorphs, tallness and shortness, were reshuffled, and in 25 per cent. cases two genes for shortness came together and produced pure-breeding dwarf peas like the dwarf grandparent, while in another 25 per cent. two genes of tallness came together, producing pure-breeding tall peas like the tall grandparent.

MENDELIAN INHERITANCE

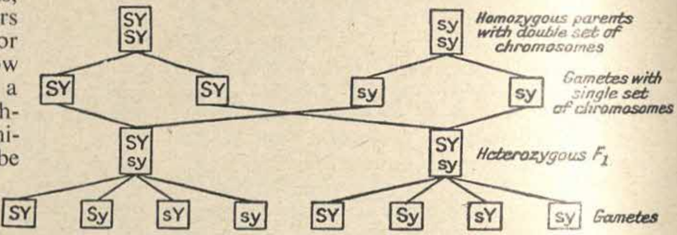


T.T. represents pure tall ; S.S., pure dwarf ; T.S., impure tall.

Another example of the dominant character is the brown eye colour which is, on the whole, dominant to the recessive blue. The student should reconstruct the above diagram in relation to these two characters, remembering that brown is dominant, and he will see why, although brown-eyed parents may have some blue-eyed children, two blue-eyed parents will not have brown-eyed children. But this conception of dominance must be modified in some cases. In the first place, certain characters, while dominant to some, are recessive to other characters. In the second, two genes carrying different characters may each be equally effective in stamping their characters on the offspring. In the latter case, we get a half-and-half effect, but not a true blend, in F_1. Thus, when a white fowl is crossed with a black, neither colour is dominant in the F_1 chicks. Instead, the F_1 chicks are what are known as blue Andalusian. This is an intermediate effect, but it is not a true blend. The blue Andalusians do not breed blue in perpetuity; but in the F_2 generation, obtained by breeding blue with blue, we get, as we should expect, 25 per cent. white, 50 per cent. blue, and 25 per cent. black. Also, many characters will depend on the combined effects of several, or many, genes, and will not therefore give a Mendelian segregation.

It is most important that the student should become familiar with the operation of Mendel's Law, as it is the basis of genetics. Next, consider what happens when parents, which differ in respect of two pairs of allelomorphs, are crossed. For instance, when a smooth yellow variety of maize is crossed with a wrinkled white kind, both smoothness and yellowness being dominant, the F_1 generation will all be smooth and yellow; but they are capable of producing gametes which will produce sixteen combinations of the four characters, smooth, yellow, wrinkled, and white. They will bear four kinds of pollen nuclei and four kinds of egg nuclei. "Wrinkled" may be considered as merely the absence of the character smoothness, and white as the absence of yellowness. It is obvious that both smoothness and the absence of smoothness cannot be present in the same gamete.

To illustrate, without using algebraical formulae, how these characters may be combined in the sixteen squares in a diagram, we write the four kinds of pollen gametes horizontally four times, and the four kinds of ova gametes vertically four times in the same squares. Using the symbols S (smooth), Y (yellow), s (wrinkled), y (white), these four kinds of gametes, pollen and ova, can be represented by SY, Sy, sY and sy in each case in the diagrams below and in the previous page. In this experiment the offspring are in this ratio of 9 : 3 : 3 : 1, though it must be stressed that ratios obtained in an experiment are never exactly the theoretical expectation. Statistical tests must be made to establish the significance of the results. It is possible to choose pairs of characters which would give widely different ratios. Those which give the 9 : 3 : 3 : 1 ratio are obeying Mendel's second law, that of the "independent assortment of germinal units," which states that "each one of a pair of contrasted characters may be combined with either of another pair."


SY
SY
sy
sy
Homozygous parents with double set of chromosomes
SY
SY
sy
sy
Gametes with single set of chromosomes
SY
sy
SY
sy
Heterozygous F_1
SY
Sy
sY
sy
SY
Sy
sY
sy
Gametes

MENDELIAN INHERITANCE AND CHROMOSOMES. If two factors SY and sy are carried by a pair of chromosomes we get the combinations shown here, which will give the dihybrid ratio of 9 : 3 : 3 : 1 in the F_2 generation.

LESSON 8

The Chromosomes' Part in Heredity

In the preceding Lesson it was pointed out that a plant bred true and was homozygous for a certain character only when it received a double dose of that character from its parents. Each of these doses was carried in one of the gametes making the individual. A heterozygote is formed of unlike gametes. These facts imply that characters are carried in pairs, but that the pairs may divide. This view is confirmed by an examination of the constitution of the germ cell, or gamete. Mendel, without the present-day knowledge of cell formation, formed a wonderfully correct view of the laws of heredity.

Chromosomes and Species

Every species of plant and animal is distinguished by the number of chromosomes carried by its cells. Some species have a large number of chromosomes, some only a few. There are species of round worms with only two chromosomes in the nucleus of each somatic cell (a somatic cell is an ordinary diploid cell, not a gamete). Some flies have a set of four chromosomes, crayfish over 200, mice 40, men 48 in their somatic cells. These somatic cells may be regarded as bearing a double number of chromosomes, hence the term diploid. It is the male sperm cell, or gamete, and the female gamete, or egg cell, which bear the haploid number of chromosomes, e.g. the human male sperm and the human female ovum each contain 24 chromosomes.

Fertilization of Sea Urchin

The male sperm is small and active, and proceeds to search for the female egg, which is comparatively large and immobile. In the sea urchin the process of fertilization has been cinematographed, and through the microscope the male sperm is seen as a small tadpole-like body moving through the water until it comes in contact with an egg. Directly this contact is made, a little protrusion of protoplasm appears on the surface of the egg, which absorbs the head only of the male sperm, leaving its tail outside to die and drop off. Once inside the egg, the nucleus of the male sperm fuses with the egg nucleus, and the two single sets of chromosomes—a set from the nucleus of each haploid gamete—join to form the diploid zygote, or fertilized cell, from which, by subsequent mitosis, or cell division, the new animal is formed. Some plants have male gametes which swim actively, though in the seed-bearing plants there is a different mechanism for the transfer of the male cells.

Chromosomes bear Heredity

Since, then, there is very little of the male gametic cell except the nucleus, with its chromosomes, it would seem that it is they, and they alone, which transmit the paternal characters to the offspring ; and, as the paternal and maternal contributions to the characters of the offspring are, on the average, equal, it would seem that the chromosomes in the egg nucleus bear the maternal characters to the offspring. That the chromosomes are bearers of heredity becomes more likely still when it is remembered how they form in pairs, and how, during the union of gametes, either member of a pair may go into the zygote. This gives exactly the same law as to the probability of the emergence of any paternal character in the offspring as Mendel discovered by experiment. Thus the Mendelian inheritance, shown in the diagram in page 59, may be explained as being due to a cross between parents one of which is homozygous for two dominant characters, smooth yellow (SY), while the other is homozygous for two recessive characters, wrinkled white (sy). If the two factors, SY and sy are carried by a pair of chromosomes, we get the combinations shown in the diagram in page 60.

The Genes

Each chromosome has been treated as possessed of or carrying one or two factors which produce unit characters, such as tallness, smoothness, etc. When, however, one thinks of the thousands of ways in which offspring resemble, or differ from, their parents, it is obvious that the few chromosomes which each parent contributes (24 in man) must each contain thousands of these factors.

The term *gene* is nowadays commonly used to describe the presumed physical or chemical unit which causes the appearance of unit characters. There is evidence that the genes have a linear arrangement along each chromosome. Microscopical examination of stained chromosomes reveals that there are darkly staining bodies along the length of the chromosome ; it is thought that these bodies may represent genes, or, more likely, groups of genes. The gene is a unit in the sense that each gene produces a specific and indivisible effect, but it is not clear whether or not it is a unit in the sense that there is physical discontinuity between one gene and the next on a chromosome. Each gene on a chromosome has a similar or comparable gene, the other one of the allelomorphic pair, on the other chromosome of the pair, in a somatic cell.

Parents' Chromosomes

One parent yields one chromosome from each of his many pairs of chromosomes, while the other parent supplies a corresponding chromosome from each of her many pairs, and these contributed chromosomes form a fully equipped cell, which divides up in the usual way to form a new individual. The new cells, and the new individual formed by them, will, however, owing to the fresh arrangement of chromosomes and genes, be different from either of its parents, although it will exhibit some of the characteristics of both.

The reader is reminded of the building up of the body by the division of somatic cells. The chromosomes split longitudinally, one half going to the nucleus of one daughter cell, the other half of the chromosome to the other cell. It is now seen that by this process every cell in the new individual gets an equal share of every gene contributed by the parents.

Law of Independent Assortment

It has previously been pointed out that when considering more than one pair of characters, the characters would, according to Mendel's second law, sort themselves out independently of one another. The results of many experiments prove, however, that certain whole groups of characters are transmitted according to Mendel's first law, instead of obeying his second law. It is found, moreover, that in breeding any organism, the number of groups of characters so transmitted agrees with the number of pairs of chromosomes possessed by the organism. Linked characters, then, are those controlled by genes located on the same chromosome. Fortunately, Mendel chose for his experiments characters located in separate chromosomes, so that he discovered the law of independent assortment.

Experiments with Drosophila

Professor T. H. Morgan (1866–1945), of Columbia University, and his co-workers investigated for some years this question of grouping, or linkage, of characters in the banana fly. This tiny fly, *Drosophila melanogaster*, whose four chromosomes have been subjected to such intense scrutiny, bids fair to out-rival Mendel's peas in biological fame. It has had this greatness thrust upon it because of its obliging tendency to produce every 10 days a family of over 200, which will live quite happily in a bottle. In the Columbia laboratory, and in many other genetical laboratories throughout the world, are rows and rows of bottles containing millions of these flies of known pedigree;

and record is kept of the particular shuffling and re-dealing of the chromosomes and genes concerned in their make-up. Flies of very many patterns have been bred—flies with white eyes, flies with pink eyes, flies with no eyes, flies with wings and without, and flies with half the body male, the other half female. Study of many experiments with linked genes eventually enables the positions of the genes to be plotted on chromosome maps. These experiments will be referred to again in the next Lesson.

Sex Linkage

It has been known since 1902 that in some animals the female has one more chromosome than the male, or that one pair of chromosomes consists of unequal partners in the male. The female has two like chromosomes, known as X chromosomes, while the male has only one X chromosome, partnered by a different chromosome, Y. The Y chromosome may be very small, as in man, or genetically inactive, as in *Drosophila*, or it may be absent altogether in some species. The female gametes, or eggs, will all contain one X chromosome, owing to reduction division (*see* page 55), but the male gametes or sperm will be of two types, (A) those containing an active X chromosome, and (B) those containing only the functionless Y chromosome.

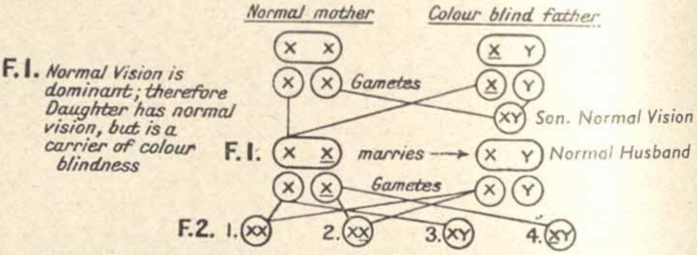
If the egg be fertilized by a sperm of the A type, the resulting zygote will have a pair of X chromosomes, and will be a female. If the egg is fertilized, however, by a sperm of B type, the resulting zygote will have only one X chromosome (which was contributed by the mother), and one Y chromosome (from the father). It will, therefore, be male. This is the mechanism of sex determination. All other sexual characters depend on the presence of the appropriate chromosomes. Since the unpaired X chromosome of the male is always passed to the daughter, all the genes or characters in this chromosome will be handed to daughters and not to sons. The sons will show the characters carried by the genes in the X chromosome contributed by the mother only.

It is known, for example, that ordinary colour-blindness in man is due to a gene carried by the X chromosome, and it is therefore known as a sex-linked character. As such it follows the rule for sex-linked inheritance. In the diagram all the other 23 pairs of chromosomes are ignored, and only the XX pair of chromosomes of the female and the corresponding XY pair of the male are shown. To indicate that the X chromosome of the father contains a gene for colour-blindness, this X is underlined. The diagram shows, as will be seen, that a colour-blind woman occurs only when a colour-blind man marries either a *carrier* or a colour-blind woman, and for this reason colour-blindness is far more prevalent in men than it is in women.

It should be noted that this sex-linked type of inheritance is somewhat different from Mendelian inheritance. The genes in the ordinary chromosomes (*autosomes* as they are sometimes called) are inherited, according to Mendel's laws, because there is a complete pair of autosomes in each sex ; but, as the male (in many species) lacks one of the X chromosomes, the inheritance of the genes in the X chromosome is sex-linked and is therefore different for each sex.

Haemophilia

There is a disease of the blood, haemophilia, which prevents it from clotting, with the result that difficulty is experienced in stopping bleeding from even a slight wound. This defect is inherited in the same way as colour-blindness. The daughters and grand-daughters of a defective male hand the disease on to half their sons (*see* diagram). Women do not suffer from the disease, though they may carry it, because the homozygous character is *lethal*, that is, a zygote receiving a double dose of the haemophiliac X chromosome never develops into an embryo.



F. I. Normal Vision is dominant; therefore Daughter has normal vision, but is a carrier of colour blindness

COLOUR-BLINDNESS as a sex-linked character. 1. Daughter of normal vision. 2. Daughter of normal vision, but a carrier of colour-blindness. 3. Son of normal vision. 4. Son colour-blind.

Transmitted by Male

Characters transmitted in this way must be carried in the unpaired X chromosome of the male, and it is by following this clue that the first step towards discovering which chromosome carried a certain gene was made. One result of the breeding experiments with the banana fly (*see* next Lesson) has been to locate more than 50 characters in its X chromosome alone. It should be noted that in some groups of animals, for instance the birds, and the butterflies and moths among insects, it is the male which has two X chromosomes and the female which is heterozygous for sex, or has X and Y chromosomes.

LESSON 9

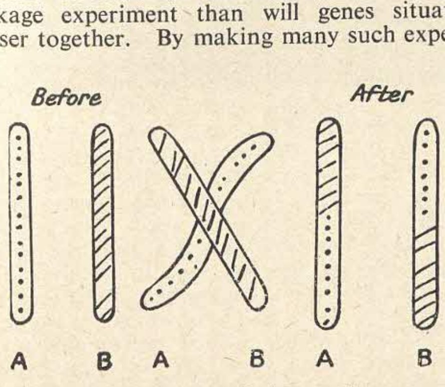
The Banana Fly and Genetics

In experimental breeding it is found that characteristics pass on from generation to generation in groups. In peas, for example, seven groups of characters are inherited according to Mendel's laws, and, since peas have seven pairs of chromosomes, it is inferred that each group of characters, or genes, is carried by one pair of chromosomes. Similarly, the banana fly, *Drosophila*, shows four groups of characters and has four pairs of chromosomes. But from time to time in their many experiments Professor Morgan and his fellow workers found that these four groups did not behave entirely in accordance with Mendel's first law. In a very small proportion of the F_2 flies in each experiment the linked characters had recombined, instead of remaining in their linkage groups.

It was found that two of the chromosomes, when lying in pairs across the spindle (*see* Lesson 2), had "crossed over," that is to say, they had presumably twisted round each other, so that when they pulled apart again a breakage had occurred in the chromosomes—part of chromosome A had been substituted for the complementary part of chromosome B, and vice versa. (The diagram below does not represent actual chromosomes, but shows, very diagrammatically, how the exchange of parts occurs.) The offspring which receive either of these chromosomes will not show the characters expected. Crossing over has taken place.

Locating the Genes

It is obvious that if two genes are located at either end of a chromosome they are much more likely to be separated, by crossing over, than are two genes occurring close together on the chromosome. Genes situated at a distance from one another will thus give a higher proportion of reshuffled characters in the F_2 of a linkage experiment than will genes situated closer together. By making many such experiments the relative positions of genes on a chromosome can be calculated. It is on these lines that actual charts of the chromosomes of *Drosophila* have been made.



Chromosomes before and after crossing over.

Furthermore, in the salivary glands of these insects are nuclei with giant chromosomes, which under the microscope have a banded appearance. To some extent it is possible to correlate the positions of genes as determined by linkage experiments with particular points on the giant chromosomes. The number of genes identified is continually increasing as investigation proceeds.

Inbreeding and Outbreeding

Most organisms carry some deleterious genes, but, since the zygote is diploid—since, that is to say, it is furnished with two sets of genes, one paternal and one maternal—a defect caused by one set may be made good by a corresponding normal gene in the other set. It is only when the deleterious genes coincide, and the defect is present in a double dose, that it appears. This is what happens in some cases when inbreeding takes place. The nearer the relationship of the parents to a common ancestor, the more likely is it that the deleterious genes in the chromosomes contributed by each will coincide in the zygote, and an offspring will be produced which is homozygous for (that is, which has received a double dose of) the defect.

No definite law can, however, be laid down as to the general effects of inbreeding. The German zoologist August Weismann (1834–1914), inbreeding mice for 29 generations, found that the average fertility dropped from 6·1 to 4·2 per litter as a result. Many lines of inbred mice have been kept successfully since then, and the level of fertility may be very different in different lines. Loss of vigour in some plants has again been proved to be the consequence of continued self-fertilization. On the other hand, deer in Windsor Park, Berkshire, numbering some thousands and descended from one male and two female New Zealand deer, showed no signs of degeneration after 80 years of inbreeding.

In man, consanguineous marriages *may* lead to disaster, but the happy results of intermarriage between members of the distinguished Wedgwood, Dalton, and Darwin families are often quoted against this view. The effects of inbreeding will depend on the genetic make-up of the stock to begin with. Out-breeding generally brings increased vigour, if it is between different stocks of the same species. Interspecific breeding does not normally occur in nature, but in some cases species can be crossed artificially, provided they are not too dissimilar. In such a case the offspring, though they may show " hybrid vigour " in other respects, are generally sterile.

The reason for this sterility appears to be that of two widely differing sets of chromosomes combined in the zygote, each will endeavour to reproduce in different directions. A familiar example is the ass, which has 64 small chromosomes, mated to a mare, which has 38 large chromosomes. The ass sperm, containing 32 small chromosomes, is able to fertilize the equine ovum, containing 19 large chromosomes, and to produce the vigorous hybrid mule. The unequal sets of chromosomes which the mule inherits cannot pair normally to form germ cells, so that the mule is sterile.

Mutation

Of great importance to the student of biology is the increased knowledge of what is known as *mutation*, which has been acquired from experiments in breeding during recent years. Changes in the structure of the chromosomes have sometimes occurred in breeding *Drosophila*. In one case, the two rod-shaped chromosomes became united and formed a single V-shaped chromosome, and a new type of fly was produced. Sometimes a portion of a chromosome will become reversed during meiotic cell divisions, and the genes whose positions on the chromosome have thus been changed may express themselves in a new way. Other new types have arisen through the alteration in the number of chromosomes. It sometimes happens in cell division that one of the new cells receives all the chromosomes (a double set), and the other none. The latter cell is abortive, but, if the cell with the double set unites in the next generation with one of the usual type, a new individual appears (with three sets of chromosomes), differing in many respects from the original stock.

In the plant world, the wild rose has 7 chromosomes ; there are species with 14, others with 21, 28, and 35 chromosomes. There are different species of chrysanthemum with different multiples of 9 (18, 36, 54–90) chromosomes. The most fundamental and important mutation, however, is that due to an alteration in the nature of the gene itself. Little is known of the cause of such alteration in the chemical constituents of a gene, but alterations have been produced by X-rays.

In many thousands of generations of *Drosophila* that have been bred, some hundreds of changes have occurred, and new ones are continually appearing. Once a gene mutation has occurred, it breeds true, in the same manner as any other gene does, and segregates in the normal Mendelian way.

Reference will be made to these mutations in later Lessons, in considering the causes of evolution. In this and Lesson 12 chromosomes and genes have been presented as the sole and all-important factors in heredity and therefore in the evolution of new types. However, the reader should suspend judgement until the question of heredity and environment has been considered in a later Lesson.

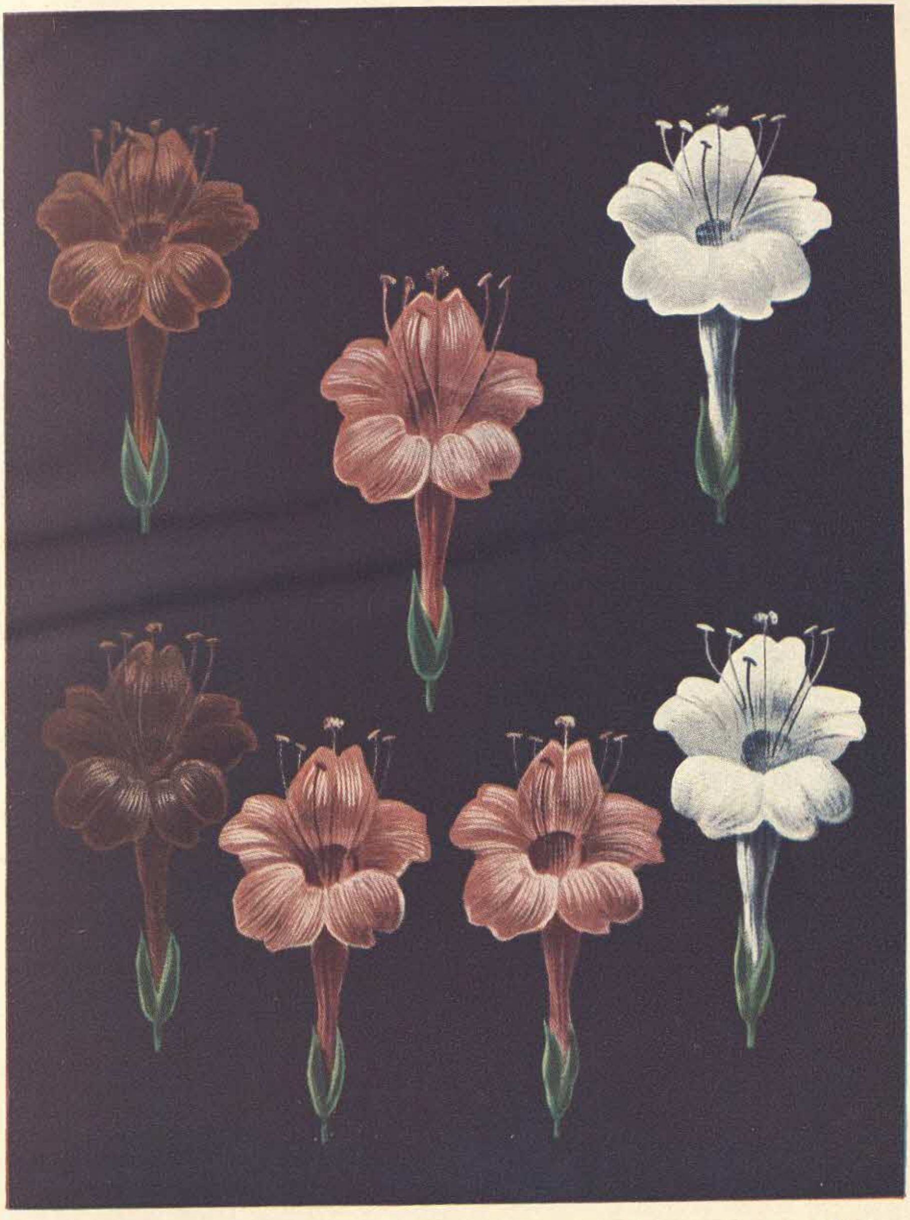
LESSON 10

Stages in Plant Evolution

IN Lesson 3 it was noted that the possession of chlorophyll was one of the features which distinguish plant from animal ; but in the microscopic world the distinction between plant and animal is not always clear. The early forms of life were probably indefinite in this respect ; they were neither clearly animal nor clearly vegetable, but, if one may judge from low forms of life of the present day, primeval organisms showed some features of both worlds.

Thus, the mat of thin white threads that covers a piece of stale bread—mould, as it is called—belongs to the plant world, although it has no chlorophyll, nor does it feed in a plant-like way. It obtains its food by dissolving organic matter in the bread and then absorbing the resultant nutritious fluid. In spite of this method of feeding, mould reproduces itself as a true vegetable should. A little spore case develops on the top of a thread and shoots out hundreds of tiny spores into the air, ready to settle on any dead organic matter and grow into another mat of mould. This fungus must therefore be included in the plant world, as *Sphaerella* (*see* Lesson 3) and other flagellates are included, although they show animal-like activity.

One can only speculate as to the habitat of the earliest plants ; they may have lived in shallow lagoons on the sea coast, at any rate in water or damp mud. They were probably one-celled, but may have formed groups of colonies of single cells, such as the *Collozoum* ; again, cell might join on to cell and form a long ribbon, such as the common seaweed. To-day vast numbers of simple plants float near the surface of the sea, and they are most important in that on them feed the small animals which form the base of the food-chains on which the economy of the sea depends. Such microscopic plants may have arisen very early in plant history. Algae remains are known from the Siberian



MENDELIAN THEORY DEMONSTRATED BY FLOWERS

The South American plant Mirabilis jalapa has white and red flowers. If a white flower with two "white" genes in each nucleus is pollinated by a red flower with two "red" genes, the resulting generation has one gene of each kind and are therefore pink flowers. When these fertilize each other reds, pinks, and whites are produced as seen here, according to Mendel's law. Reds and whites breed true, but pinks produce reds, whites, and pinks.

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period, and remains that may be of algae from very much earlier. The bacteria also probably arose very early, for the processes of decay depend on them, and they seem an essential part of any natural economy.

First Land Plants

Early in the world's history, owing perhaps to the rising of the sea bed, some aquatic plants began to adapt themselves to life on land. It was necessary to develop a root-system capable of absorbing water, instead of merely a hold-fast, as the seaweeds have. Since the plants could no longer be supported by the water, the stems had to be made of stouter stuff, and some early plants threw up a shoot from their underground stems to a height of 20 inches. The shoots of the early forms carried no leaves, but terminated in a spore capsule, like that borne by bread moulds, moss, and ferns of to-day. The spore capsules of *Hornea*, one of the earliest land plants, were merely modified branches, and they exemplify the beginnings of structures specially adapted to carrying the non-sexual reproductive cells. Some of the structural features of the plant are distantly akin to those of seaweeds. Those early leafless land plants bore on the stem breathing pores, or stomata, by which the plant obtained carbon dioxide from the air.

Another species of primal land plants, *Asteroxylon*, bore scales on the stem, which developed into spiny leaves on the higher shoots. There can be seen traces of veins running through these leaves, and this species, although found in the same geological strata, shows a structural advance on *Hornea*. Further details of these plants are given in Lesson 12.

Steps in Plant Evolution

Having moved from the water to land, which may have happened on more than one occasion, by a series of steps, plants at last managed to fertilize their seed without the intervention of water. The water plants shed their reproductive cells into the surrounding water. The two different processes of reproduction practised by the one-celled water-vegetable *Sphaerella* are described in Lesson 3. The single cell of *Sphaerella* usually divides and becomes four new individuals. This is the non-sexual method of generation. At times, however, the mother cell divides into 32 smaller individuals which swim, by means of flagella, towards each other, and pairs of them fuse to form another individual. This is a primitive form of sexual reproduction. Other algae also reproduce either by spores or sexually.

Similar reproductive processes are practised by land-dwelling plants, but alternate, so that one generation reproduces asexually, by spores, and the next sexually, with fusion of gametes. The spore is a tiny piece of living tissue which reproduces without fertilization. A fern spore germinates in damp ground; it does not produce a fern but a small plate of green tissue, shaped something like a miniature bicycle saddle, which is called a *prothallus*. This tissue develops, on its under side, male and female gametes. The former are active, and swim, by means of flagella, through the drops of moisture on the underside of the prothallus towards the female gamete. The female gamete is a single cell contained in a sac-like structure. Fertilization takes place and a new fern is the result. This alternation of generations—(a) non-sexual spore-bearing fern, (b) gamete-bearing prothallus—needs the intervention of water to enable the male cell to swim towards the female egg. Thus the early plants had to live in bogs and on the riverside, just as moss and ferns keep to moist places to-day. It was usual, then and now, for the spore-producing organs to be elevated to the highest extremities of the plant, so as to ensure a wide distribution of the spores; the prothallus is small and close to the ground so as to be in the necessary damp environment.

Mosses and Ferns

Horsetails, ferns, and club mosses, types of some of the earliest known plants, all produced spores and prothalli. The horsetails, unlike the true mosses, had large vascular stems (i.e. stems containing pipe cells for the conveyance of water and food), and formed mighty trees in the Coal Age. The modern horsetails produce spores all alike, which, however, germinate into a male prothallus if they fall on poor soil, but form a female prothallus if the soil is rich.

One species of club moss, the lycopods of to-day, sheds an immense number of spores (the lycopodium powder used in fireworks). These spores are all of one kind, but many species of fossil lycopods bore small male spores (microspores) and large female megaspores. In the club mosses the female prothallus develops within the enclosing skin of the megaspore, and accumulates a food store before the megaspore is shed. This process, it will be noted, is a step nearer the production of a seed, though fertilization still depends on the swimming of the male gamete to the female prothallus from the male one. An ancient species of giant lycopod, *Lepidodendron*, is described in Lesson 12. These plants (ferns, horsetails, lycopods), which produce spores and prothalli, are grouped as Cryptogams (plants which " hide their marriages," as opposed to the seed-bearing Phanerogams which make " visible marriages"). The next step in plant evolution is the retention of the female prothallus, thus forming a seed, borne on the plant.

Another very important group of ancient plants, Pteridosperms or seed-ferns, was for a time confused with the cryptogamous true fern, because the impressions of its foliage found in the coal measures were very like those of the true fern. Unlike the true ferns, however, the seed-ferns retained the megaspore on the leaf and the seed formed inside a seed-coat, which had a small opening. The arrangement in primitive Gymnosperms, such as the living *Cycads*, is similar. The male spores, or pollen grains, are borne by wind to the opening of the megasporangium. Water is provided in the seed chamber, through which the male gametes swim to fertilize the seed. In the highest type of Gymnosperms or naked-seeded plants—the conifers—the male prothallus is reduced to a pollen-tube, and the male gamete has, accordingly, no need to swim. The loss of this relic of the ancestral aquatic habitat is another step in plant evolution.

The Angiosperms (sheltered-seeded plants) have evolved a still further stage. Their method of fertilization is described in Lesson 6. The male spore leaf has become a stamen, and the female spore leaf forms the carpel, which shelters the seed and embryo. To-day there are some 125,000 species of Angiosperms, nearly 2,500 species of Gymnosperms (pines, firs, etc.), and about 3,000 species of ferns. There are also many other lowly forms of plant life, such as algae, fungi, mosses, and liverworts.

LESSON 11

Signal Steps in Animal Evolution

The animal kingdom also shows certain obvious steps in the elaboration of structure or of habit. Not all of these are known from the direct evidence of the fossil record, but can be inferred from the existence of a variety of forms to-day. Most of the main animal groups were already established when the fossil record begins in the Cambrian period ; within these groups, quite a lot may be known about the history of those animals which had hard skeletons, and so left fossils, but very little about animals which were soft-bodied and therefore rarely fossilised.

Plant life must have preceded animal life, for reasons discussed in Lesson 3. The earliest animals must have been forms which we would to-day classify as Protozoa, though they need not have resembled the modern Protozoa. It should be remembered that one cannot build an evolutionary series from modern forms, which represent the tips of the twigs of the family tree. It may be possible, however, to infer the shape of the tree from the position of the twigs ; fossil forms will give a more accurate estimate of the position of the branches.

Formation of Colonies

The next step was that taken by the one-celled animals to overcome the limitations imposed by their small bodies. This step could be achieved, in some sense, by the formation of a colony of one-celled creatures ; the united cilia of a colony of cells would draw a large volume of food to each individual cell. In a colony there could also be a division of labour, to some extent. A more efficient system could be achieved if, instead of forming a colony, the products of cell division remained aggregated in a single body, with the development of a similar division of labour, which could be more efficient owing to the closer association of the parts. For instance, the outer layers of cells could become protective, the inner could be concerned with the assimilation of food ; while the function of reproduction could be limited to certain cells only. Thus the gap between one-celled and many-celled animals would be bridged. This has certainly happened twice, for the sponges are so dissimilar from the other multi-celled animals that they cannot be closely connected, yet they have resemblances to some Protozoa in cell structure.

Division of Labour

A two-layered structure of cells, outer and inner, is the usual form in the creatures known as Coelentera, the cells being specialised into stinging cells, digestive and muscle cells, and nerve cells. Not all the Coelenterates are strictly two-layered ; reference should be made to the Course on Zoology for further details. They are certainly simpler in gross structure than the other Metazoa, and used to be considered primitive ; recently it has been suggested that they may have been derived from flatworms by a secondary simplification of development, losing the embryonic *mesodermal* layer.

This three-layered construction is found in a rudimentary form in the flatworms, and it is the common type of structure in the higher groups. The flatworms have no circulatory or respiratory systems ; their bodies must therefore be flat and thin, so that, as in a tree leaf, all the tissues receive oxygen easily from the surface. The gut is branched to all parts of the body to facilitate the distribution of food, but, as well as a diffuse nerve net, the flatworms have a central nervous system with head-ganglia and nerves. In other groups of worms there is a *coelom* (a space developed from the mesoderm, or middle layer of cells which is the body-cavity). The worm group is further distinguished by a blood system, a posterior opening of the digestive tube, and a segmented body—features common to the higher phyla.

The steps considered so far have been of structure; there are also steps between one type of habitat and another, which involve adaptive changes in structure and physiology. There is, for instance, the step from sea water to fresh water, which demands an ability to control the concentration of salts in the blood, and to keep this concentration above that of the surroundings. This step has been taken by some Protozoa. It is probable that the main centres of Metazoan evolution were in the sea. Most sponges also are marine, though a few are fresh water. Of the Metazoan phyla, most have both marine and fresh water forms, though the Echinoderms and the Protochordates (the sea-squirts) among Chordates are exclusively marine.

The ability to live in fresh water, in most cases, would have preceded the ability to live on land (there are a few exceptions among shore-living animals). Some worms are terrestrial, but are confined to damp environments, usually in soil. The main problem to be solved when becoming terrestrial is to prevent drying up ; relatively few animal groups have solved this problem successfully.

Adaptation to Land Life

The adoption of a terrestrial life involves the use of atmospheric oxygen for breathing, instead of that dissolved in the water. The respiratory surface must nevertheless be damp, for the oxygen must be dissolved in water before it can actually be transferred to the tissues. The necessity of maintaining a large damp surface to breathe through is the source of the danger of drying up, for in a dry atmosphere water may evaporate from such a surface more quickly than the animal can replace it.

The loss from evaporation will be cut down if the respiratory surface can be tucked away inside the animal so that at least it is not exposed to moving or unsaturated air. Accordingly, snails have their respiratory surface in a special cavity within the shell, with only a small opening to the outside air. Woodlice, whose aquatic relations have thin-walled gills beneath the abdomen, modify the overlying gill plates to protect those lying beneath ; furthermore, air may be carried within the body by tubules growing in from the exoskeleton of the gills. The latter device is adopted also by the more successful terrestrial Arthropods, the insects, and also by the Myriapods and certain Arachnids.

The air tubes are called *tracheae*, and where fully developed ramify to all parts of the body, conveying air directly to the moisture at the ends of the tubes, which are embedded in the various tissues. There the oxygen passes into solution, almost at the site of its utilisation. This mechanism is very efficient provided there is not too long a distance between the opening of the air tube and its termination, which makes difficulties in ventilation. Many insects develop air sacs on the tracheae and aid ventilation by pumping movements of the body. There is usually a one-way circulation, air entering at some *spiracles* (the outer openings of the tubes) and leaving at others. Water loss through evaporation can be reduced by closing the spiracles if necessary, the body surface being impermeable.

Effect of Gravity

Another complication in terrestrial existence is the increased effect of gravity as compared with living in water. The weight of an animal in water does not matter much, but may be a factor limiting the size of land animals. The Arthropods have an exoskeleton which not only forms an armour covering the body but also has to provide attachments for all the muscles moving the various joints; it is probably the disproportionate weight of the skeleton in large Arthropods which limits the size of the terrestrial members of the group. The difficulty of large-scale tracheal breathing is probably also a factor, but that can be avoided to some extent if the body is long and thin.

Thus, the longest living insect is a stick-insect which reaches 13 inches in length; the Hercules beetle is only about half as long, but much more bulky. The largest known insect was a dragonfly living in the Carboniferous period; the wing span was two feet and the length of the body about one foot. The effect of gravity also determines the proportions of land animals, in that large animals must have relatively stouter legs than small ones. A comparison of, say, a goat and an elephant should make this clear. The reason is that while the weight increases as the cube of the linear dimension, the bearing power of the legs depends on their area of cross section and so increases only as the square of the linear measure. An animal much larger than an elephant would have to have legs so thick they could scarcely be accommodated under the body ! This is why it is thought that the very large dinosaurs probably lived in swamps where the water would support their weight.

First Terrestrial Vertebrates

The first terrestrial vertebrates did not have to solve the air-breathing problem, because the fish from which they arose already had lungs; even to-day some tropical fresh-water fishes breathe air, by a variety of devices, as oxygen is often very scarce in the waters in which they live. However, only the adults of these fishes, and of the Amphibia to which they gave rise, had lungs, and it is therefore necessary for the Amphibia, to this day, to return to water to breed, as the frogs and toads do.

Furthermore, most Amphibia have moist skins and are therefore in danger of desiccation, just as are the less successful terrestrial invertebrates. The reptiles, which arose from the Amphibia early on in the history of the latter group, have dry skins, so solving the water-loss problem, and, more important, they laid eggs which could develop away from water. Reptile and bird eggs are large and shelled, containing a store of food and water which enables the young animal to reach an advanced stage before hatching. Reptile and bird eggs also have special membranes in the egg—(a) the *allantois*, or embryo's breathing organ, which is also used for storing excretory products, and (b) the *amnion*, a protective water cushion.

The Mammals

A further development of the allantois—the placenta—is found in mammals. (It is described in the Course on ZOOLOGY.) Viviparity (live birth) is advantageous owing to the protection gained by the young. It occurs sporadically in many animal groups besides the mammals. The warm-blooded condition (which also occurs in the birds) makes the mammals more independent of their environment than other vertebrates. The higher mammals, especially those that took to tree life, depend for success on their power of vision and delicacy of touch, demanding highly developed visual and tactile organs and a corresponding agility, with good motor control.

Dominance of Man

All this leads to increased manual dexterity and greater brain development, and tends to develop the sense of sight rather than that of smell, which is the main pilot of ground mammals. The tactile, visual, and association centres of the brain show a continual increase in size if we compare lemurs with monkeys, monkeys with apes, and apes with men, while the centres connected with smell show a relative decrease. Of the mammals, man, owing to his large brain, is dominant, although biologically, he is a newcomer. Each new structural feature has given its possessor a wider environment and greater experience, and man, with his complex brain and nerve structure, has achieved consciousness of his experience and of his power to extend it.

Power of Flight

The power of flight has been developed by birds and bats and certain extinct reptiles, and of course by most of the insects. Various other animals are able to glide, without actively flying. Many terrestrial animals have also returned to the water, for instance certain snails, insects, and spiders, turtles, and sea-snakes, and some extinct reptiles, penguins, and several mammals, most notably the whales, some of which, released from the effects of gravity, have developed into the largest animals there have ever been.

Degeneration

It must be remembered, however, that all adaptation has not been in the direction of progress. Nearly all plants and animals that have adapted themselves to a parasitic life have degenerated in structure in the process. The crustacean *Sacculina*, for example, begins its life as an active larval crustacean. It has a chitinous skeleton, jointed limbs, and eyes and a heart like those of young lobsters and crabs. After moulting, however, it fastens itself to some adult crab, on which it settles for life. It develops root-like organs, which penetrate to all parts of the body of its host, it loses eyes and limbs, and degenerates into a bag of eggs nourished from the blood of its victim. Since these parasites are highly successful, and have very complicated life-histories, most authorities prefer to regard them as "specialised" rather than "degenerate." Highly developed sense organs and so on are a necessary consequence of a free-living habit, but animals adapted to a sessile existence are not necessarily any less successful.

LESSON 12

Fossil Evidence of Evolution

In studying the evolution of plant or animal life, the reader is at once confronted with the difficulty of appreciating geological time, and of realizing the relative magnitudes of the vast eras into which the existence of the earth has been divided. To enable the reader to follow this Lesson, these eras have been set out in a table in the facing page, beginning with the most recent. More detailed time scales are in the Courses on GEOLOGY and ZOOLOGY.

Very little evidence of life has been found in rocks of the Eozoic era. This is not surprising, since violent volcanic upheavals have torn, contorted, and tilted these early sedimentary rocks. Moreover, the plant life of this era, if plant life there were, must have been without any woody structure, so that no certain traces of vegetable life have been found in Archaeozoic rocks and only traces of Algae in Proterozoic strata. Beds of graphite (carbon) are found in

Archaeozoic rocks, however, which in all probability are composed of the remains of lowly marine plants.

Early in the Palaeozoic period plants must have taken to the land, for remains of land plants have been found in Upper Silurian deposits. Discoveries in the rocks near Rhynie, in Aberdeenshire, furnish records of some of the earliest known plants (*Hornea* and *Rhynia*). *Rhynia* grew from 7 to 20 inches in height, and was unlike any plant of to-day. It had no leaves, it was rootless, and its underground stems sent up shoots which bore no true seeds, but spore capsules only. *Hornea* had tuber-like swellings on its underground stems, and the structure of the spore capsules was different, but otherwise its appearance was similar to that of *Rhynia*. Both plants grew in bogs; a third plant which grew in the same bog had leaves only on the lower part of the stem. These slender rush-like plants were, as far as is known, the sole relief to the bare rocky landscape of the early Devonian period of three hundred million years ago. Only in the rivers and pools and in the sea was there any animal life.

Carboniferous Period

Fossils of large trees are found in rocks which were laid down at the end of the Devonian period and at the beginning of the Carboniferous period. These trees are placed in the five following groups: (1) true ferns; (2) Cordaitales —a group which is related to the conifers of to-day; (3) the club-moss group, which in the late Devonian period and Carboniferous period grew into trees 90 feet in height, although their representatives of to-day are lowly plants of only one to two feet in height; (4) Calamites, or horsetails, which, represented to-day by a single humble genus, *Equisetum*, also grew into trees; their stems, however, like those of the club mosses, were of primitive structure, and were unable to carry large spreading branches; (5) Pteridosperms, or seed-ferns. There are no living members of this group to-day, but in the Carboniferous period it was a dominant type of vegetation. The leaves of this group were fern-like, but, unlike the true ferns, the pteridosperms bore seeds which were attached to the ordinary leaf of the plant; and there were no cones or flowers such as are borne by the higher plants. In virtue of the structure of the stem and reproductive organs this group forms a connecting link between ferns and higher plants.

Some coal was formed before and after the Carboniferous period, but it was in this period, when the Lycopods, or club mosses, and the horsetails flourished at their best, that the bulk of the coal deposits was laid down. These two groups, together with the Pteridosperms, formed the lush forests of the time. In the Victoria Park, Glasgow, are preserved some of the huge fossil stems of *Lepidodendron*, a genus of Lycopods. Their underground structures are unlike the roots of the trees of to-day, the leafy stem at the base dividing into four main divisions or " roots," each of which subdivided into two, and these again into two, and so on. The surface of these big roots was covered with rootlets, which appear to have drawn nourishment from the surrounding decaying vegetable matter, for these rootlets are found to have pierced to the heart of other fossilised woody stems. The climate of the Carboniferous period must have been a kindly one for vegetation. The comparative absence of annular rings in the petrified stems suggests only small variations between winter and summer temperature.

ERAS	PERIODS	LIFE FORMS
Cenozoic	Recent	Man
	Pleistocene	
	Pliocene	Age of Mammals
	Miocene	
	Oligocene	
	Eocene	
	Palaeocene	
Mesozoic	Cretaceous	Angiosperms
	Jurassic	Birds (and Mammals)
	Triassic	Cycads and Bennettitales
Palaeozoic	Permian	Pteridosperms
	Carboniferous	Reptiles, Insects
	Devonian	Amphibians
	Silurian	Cryptogams
	Ordovician	Fishes
	Cambrian	Invertebrates
Primeval or Eozoic	Proterozoic	Few fossil traces of life. Algae
	Archaeozoic	Possibly without life

During the many million years which make up the Carboniferous period these forest lands slowly sank, were inundated, and their vegetation drowned and silted over. In places the surface rose again, and a new forest grew over the site of the earlier one, and so on, till now there are coal seams which together are many hundreds of feet in thickness.

At the end of the Carboniferous period a large part of the southern hemisphere became covered with ice, and the climate of the northern world became drier. Fossils of this period (Permian) show that in the southern hemisphere a shrub-like species of Pteridosperm (known as *Glossopteris*) flourished, which seems to have been able to grow in a cold and dry climate.

Mesozoic Era

The two characteristic groups of fossil plants of the Mesozoic era are the Cycads and Bennettitales. The former had, and have, a thick stem surmounted by a crown of palm-like leaves, with cones something like those of pine trees; but the Bennettitales had reproductive organs which were bisexual, like many flowers. It was not until the Cretaceous period that the flowering plants appeared in the fossil record; as the partnership between flowers and insects became more specialised, so the flower-bearing plants (Angiosperms, bearing seeds in carpels) became the dominant species of vegetation (*see* Lesson 10).

The method of fructification practised up to, and including, the Carboniferous period was that of separate spore and prothallus and active swimming spermatozoa. Ferns, liverworts, and mosses still use this ancient mode of fertilization, but from the Carboniferous period onward seed-bearing plants developed, first with cones, later with flowers and fruits. The higher plants (monocotyledons—with one-lobed seed, e.g. grasses and palms; and dicotyledons—with two-lobed seed, e.g. trees, peas, and beans) have converted the male spore leaf into a stamen, and the female spore into a carpel or ovary.

Animal Fossils

Early forms of life in the Eozoic period, whether animal or vegetable, were for the most part soft-bodied and left little trace of their existence in the rocks. Deposits of iron found in Proterozoic rocks are thought to have been precipitated by the action of bacteria; in the later rocks of this era, microscopic spicules of many kinds of sponges are found, and worm tunnels show the existence of worms.

In the Lower Cambrian rocks there is abundant evidence of life, already with representatives of most of the phyla. Among the fossils of the period are trilobites—primitive arthropods, looking superficially something like the woodlouse of to-day, which later branched out into many new families, reaching their apex of diversity in the Ordovician period and becoming extinct in the Carboniferous.

The phylum Echinoderma is represented by fossil sea-lilies (crinoids), which are attached by a stalk to the sea floor ; they must have fed themselves by means of cilia, as their descendants do to-day. In the Middle Cambrian rocks there are traces of sea-cucumbers; and the higher forms of this phylum—starfish, brittle stars, and sea-urchins—appear in the Ordovician rocks. The soft-bodied worms are also present as burrowing worms, bristle worms, and arrow worms. In addition, there were lamp shells (Brachiopoda) and some lower members of Mollusca, but no fishes or land animals.

First Vertebrates

In the Ordovician rocks the first vertebrates appear, though known only by fragments of their bones. These were Agnatha, jawless fishes. By the end of the Devonian period some vertebrates had left the water to live an amphibious life. The Devonian period is often called the "Age of Fishes," for there were many fish forms both in fresh water and, later, in the sea. Probably the earliest vertebrates lived in rivers. These early amphibians possessed legs with five digits. The Labyrinthodonts were bulky creatures with enormous heads and stumpy tails, but with short weak legs which could not have lifted their bodies from the ground; they could therefore only have shuffled over the mud. It is known from which group of fish the Amphibia were derived, and it is possible to make a good guess at the details of how a five-toed limb evolved from their fins. The fossil evidence also shows how closely the skulls of the early Amphibia resembled those of the appropriate fishes.

Earliest Insects

In the Silurian or Early Devonian period the arthropods left the water and learned to fly. In the Carboniferous rocks insects of an advanced type are found. There was one species, unlike any insect of to-day, from which the present-day locusts may be descended; another probably was an ancestral cockroach; and a third, *Meganeura*, was a dragonfly with wings measuring two feet from tip to tip.

Appearance of Reptiles

The earliest fossils of reptiles are from Upper Carboniferous rocks in New Mexico. Just as the seed-bearing plant is more independent of water than the spore-bearing, so the reptile was superior to the amphibian. The reptiles lay large hard-shelled eggs, which contain two protective membranes—the allantois and the amnion. The hard shell of the egg makes it necessary that the egg should be fertilized before deposition. Early reptile fossils look very like some of the Amphibia, but are distinguished by the lack of traces of aquatic larval stages. Later forms can be distinguished from the Amphibia on characters of their bones as well.

Two Lines of Development

In the Permian period reptiles had already branched into several lines, especially into two, one of which gave rise eventually to mammals, and the other to the modern reptiles and the birds, and the dominant reptiles of the Mesozoic rocks, where fossils are found of carnivorous aquatic, terrestrial, and aerial reptiles.

The ichthyosaurs, aquatic reptiles of the Mesozoic, had paddles, the bones of which, although compressed for paddling, were derived from a five-toed limb. These animals looked like the dolphins of to-day. Some fossil evidence shows that they were viviparous (a useful aquatic adaptation).

The dinosaurs were land reptiles, which persisted throughout the 100,000,000 years of the Mesozoic era. They branched into many orders. Some of the earliest species ran on their hind legs only, with tail outstretched as counterbalance; others leapt in kangaroo fashion. The *Saurischia* of Jurassic and Cretaceous rocks developed such huge bulk that they reverted to four-footed progression. The fossils of *Gigantosaurus* found in Africa are those of an animal weighing from 30 to 40 tons. *Diplodocus*, another unwieldy herbivorous reptile, had a tail 40 feet in length, with which it defended itself against such enemies as *Tyrannosaurus*, an immense carnivorous reptile of the period. The largest of the dinosaurs could hardly have supported their immense bulk on dry land. They probably lived in marshes, lakes, and rivers, so that the water relieved their legs of some of their crushing weight. Their brains were very small; the brain of the *Stegosaurus* has been calculated at 2½ oz.; that of the most gigantic reptiles probably did not exceed 2 lb. Bulk for bulk, this would give the reptiles one-thousandth of the brain weight of the normal man. There are far too many Mesozoic reptiles to be considered here, and reference should be made to the Courses ZOOLOGY and GEOLOGY.

Evolution of Flight

A branch of the reptiles took to the air during the Mesozoic era. They developed from the side of the body a membranous fold of skin which was stretched along the fore limbs and extended by a greatly lengthened fifth digit. The other digits were of normal length, and provided with hooked claws for climbing, bat-like, up to a height from which to " take off." *Pterodactylus* (Upper Jurassic) had a short tail, but earlier species had a long tail with a balancing plate at the end.

Archaeopteryx

Reptile forms also gave rise to *Archaeopteryx* (Upper Jurassic), the earliest representative of birds. *Archaeopteryx* possessed true feathers along the hinder side of the fore limbs and on either side of the lizard-like tail. This primitive bird still kept its reptilian teeth, but the first digit of the foot had become opposable, and it could perch on a bough. One fossil of this bird is preserved in Berlin, the other in the Natural History Museum in South Kensington, London (*see also* the Course on ZOOLOGY). Other fossil birds are found from the Cretaceous onwards.

Owing to climatic changes, the age of reptiles ended with the Mesozoic era, and the many orders of reptiles of that time have to-day dwindled to four. Early mammals already existed in the Mesozoic, but fossil remains are extremely rare and mostly consist of small teeth. They must have been derived from the descendants of the mammal-like reptiles of the Permian, though the known forms of the latter tend to be large and specialised.

LESSON 13

Evolution of the Horse

REFERENCE is made in this Lesson chiefly to the age of mammals, the Cenozoic or Tertiary era, which stretches back some 75 millions of years from our own 20th century. This era is generally divided by geologists into the Palaeocene, Eocene, Oligocene, Miocene, Pliocene, Pleistocene, and Recent.

The lapse of time since mammals became the dominant life-form in the Palaeocene period may be appreciated if it is realized that at the beginning of the Cenozoic period great mountain systems such as the Pyrenees, Alps, and Himalayas were unformed. It was not until the Miocene period that the Himalayas began to rise. The region of Colorado has slowly risen 11,000 feet since the beginning of the Oligocene period, and since then the Colorado river has carved out a gorge, the Grand Canyon, 6,500 feet deep.

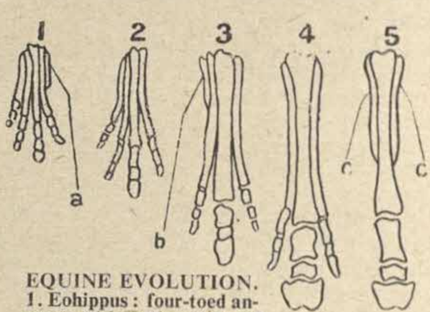
The early mammals were small insectivorous or omnivorous animals with unspecialised teeth. Several mammalian lines of the Jurassic and Cretaceous died out by the Eocene. In the Cretaceous, about 100 million years ago, both marsupial and placental mammals had appeared. By the end of the Eocene many of the modern orders of placental mammals had been established. The small early mammals had short clawed feet, which later, as different species radiated from the original stock, became feet specialised for digging, swimming, running, or tree life.

In one group of these mammals the last phalanx of each digit was almost completely covered with horn, and from this group are descended the orders of living ungulates, or hoofed animals, represented by the horse, the sheep, and the elephant; this group also gave rise to several other lines, a few of which survive to-day. The horse line is so well known, being represented by abundant fossil remains, that it is taken as an example of an evolutionary series.

Ancestry of the Horse

The starting-point of the horse line was *Eohippus*, the " dawn horse," properly called *Hyracotherium*, which is found in lower Eocene deposits of Europe and North America. These were little fox-like animals (shoulder height 11 ins.), with four little hoofs, digits II, III, IV, and V on the hand or fore foot, and three hoofs on the hind foot; but some fossils show, in addition, two splint bones on the hind foot as vestiges of digits I and V. On both feet, digit III was the largest and strongest, digits II and IV slightly smaller and equal but capable of spreading outwards and supporting the small body on soft ground. It was the North American *Eohippus* which gave rise to the later horses, the European line evolving in a different direction and later becoming extinct.

Mesohippus of the Lower Oligocene was nearly as big as a sheep (6 hands or 24 inches at the withers), though some species were smaller. Digit V is reduced to a splint bone on the fore foot, so that both feet are now tridactyl with digit III much the best developed. This type of "horse," like its ancestors, lived in woodland and was better able to walk on soft ground than the later horses. Its teeth were short, and were not yet elaborated for grinding, as they are in the modern horse. *Mesohippus* must have browsed on leaves of bushes and the soft vegetation of the river bank or marsh.



EQUINE EVOLUTION.
1. Eohippus : four-toed ancestor with vestige of digit I (a) (Lower Eocene) ; 2. Orohippus : no vestige of digit I (Middle Eocene) ; 3. Mesohippus : digit V (b) reduced to a splint bone (Lower Oligocene) ; 4. Pliohippus : digits II and IV (side toes) off the ground (Upper Miocene, Early Pliocene) ; 5. Equus : digits II and IV reduced to splints (c) (Upper Pliocene to present day).

The late Oligocene *Miohippus* seems to be a direct descendant of *Mesohippus*, and is very similar. It gave rise to several lines of horses during the Miocene. Some of these remained browsing horses. *Anchitherium* spread to the Old World and was successful there throughout the Miocene, after which it died out.

Hypohippus was a similar American form, which lasted until the Lower Pliocene, and also spread to the Old World after *Anchitherium* had died out. One line of American horses took to grazing instead of browsing. Grasses were probably becoming much more common during the Miocene. *Parahippus* (Lower Miocene) and its descendant *Merychippus* show a change-over from browsing teeth to teeth with high crowns and ridges, filled with cement, suitable for grinding hard grasses. They still retained three toes.

Main Line of Ancestry

The main line of horse ancestry is represented in the Upper Miocene and Early Pliocene periods by *Pliohippus*, of which 16 species are known. Some of these species still show two small side toes with perfectly formed hoofs, which do not, however, touch the ground, while in later species these two toes have become mere side splints, as in the modern horse ; *Pliohippus* is equipped, as regards teeth and feet, for life on drier ground or open steppe. Other descendants of *Merychippus* retained three toes. *Hipparion* was a successful form which spread to the Old World and was common there throughout the Pliocene. Its descendants persisted with the Pleistocene but then died out.

By the Upper Pliocene period true horses had evolved. *Plesippus*, a genus of the Late Pliocene period, is very closely related to *Equus*, the true horse ; they show the maximum modification of structure for speed. Every superfluous bone has gone, and those which remain are correspondingly strengthened. Thus the two bones of the mammalian forearm, which were present in the earlier fossils of this series, have become welded into one bone. The animal has lost the radial action which the human forearm possesses, but the limb and muscles are specialised for rapid fore-and-aft movement. Only the last joint of the middle toe, encased in a horny development of the toe nail, touches the ground. The palm has been welded into one bone—the cannon-bone; the wrist, above the ground, forms the " knee " of the modern horse.

Tooth Development

Corresponding gradations of skull and teeth are shown by fossils preserved in the Natural History Museum, New York. The molar and pre-molar teeth (pre-molar teeth are the molars which are preceded by milk teeth) of a modern horse are very large and, unlike our own, continue to grow for the first eight years after cutting. Their surface consists of ridges of hard enamel, between which are cavities filled with a cement which is not quite so hard. As the horse chews hay and tough grass, the cement wears away at a slightly faster rate than the enamel and dentine. Thus the surface is always corrugated, and forms an excellent grinding face.

The teeth of *Eohippus* and its successors show gradual but continual advance from a low-crowned, smooth-topped type with no cement filling to the very efficient grinders of to-day. First, the molars become adapted for chewing, then the pre-molars of the adult follow the same pattern, although the milk teeth are smooth. Finally, in *Pliohippus* and from *Pliohippus* onwards, the baby pre-molars are also elaborated.

A parallel story could be told of the evolution of other animals—camels and deer, for example—but the horse has been chosen because its fossil record, especially in North America, is remarkably complete. The story of the evolution of the horse fully corroborates that of the plant life of the Cenozoic era. From the beginning of the Miocene there was a decrease in the rainfall and a consequent shrinkage of wooded areas. Throughout the Pliocene these drier conditions were accompanied by a gradual lowering of the temperature and the formation of steppe and tundra areas, with tougher and drier food for the ungulates. Hence the need for large grinding teeth. In the open steppe-like country the attack of carnivores could be avoided only by the development of swift running and consequently of the modified legs and feet adapted for hard ground.

LESSON 14

The Story of Human Evolution

FOSSILS of early man and of the anthropoid apes are rare, and it is impossible, up to the present, to give as detailed an account of the evolution of man as of the evolution of the horse. Fresh discoveries are continually being made, however, and many of the changes involved in the development of the physical characters of mankind can be traced. One of the most obvious characteristics separating modern man from the apes is the size of the brain ; but there is a certain amount of evidence suggesting that the development of an upright posture, allowing free use of the hands, may have preceded the increase in size of the brain.

The growth of the brain appears to have been facilitated by man's relatively slower rate of development. The gestation period in man is 280 days, as compared with 220 days, or less, for apes. With the generally slow development there is a delay in the hardening of the skull, and therefore a greater period during which the brain can grow : the sutures between the bones of the human skull do not completely close till the 30th year. In apes these gaps are closed, and the size of the skull is indubitably fixed, at the age of 10 or 12 years.

A common characteristic of the skulls of apes and early men is the presence of bony ridges over the eyes ; these supraorbital ridges are very prominent features in the skull of adults, though not in young skulls. They are prominent in the Neanderthal and Rhodesian skulls, for example. The resemblance of the skull of modern man to those of the children of ancient men, and of apes, is one of the reasons for considering man *neotenous* ; this subject is discussed in the next Lesson.

Apes and Men

Man is a member of a group of climbing mammals, the order Primates. His front limbs firmly fixed at the base by a collar bone, his grasping hands, flat nails, and certain features of his brain, place him in the same group as monkeys and apes. The most primitive representatives of this group to-day are the lemurs, fossils of which are known from the Eocene period onward. Lemurs live to-day chiefly in Madagascar, which, like Australia, has been isolated from the rest of the world, so that higher forms have not reached it.

An allied animal—the tarsier—living in the Philippines, has a flat face, large forward-looking eyes, and the power of holding itself erect and leaping on its hind legs. From some such lowly form as this evolved the separate branches of the Primates—monkeys, apes, men.

Early Ancestors ?

The apes are specialised for arboreal life and have long, very muscular arms ; a Miocene ape, *Proconsul*, found in Kenya in 1948, is less specialised in this direction than the modern apes. Probably human ancestors were never ape-like in this respect, the lines diverging before the tree-living habit had fully developed in the ape line. In South Africa remains have been found of creatures, called *Australopithecines*, which walked upright, as men do, though their brains were very much smaller than those of modern men, indeed only slightly larger than ape-brains. The teeth, though larger, were human in character.

Unfortunately the date of these fossils is not known with any certainty, and they may not be old enough to be human ancestors.

Java and Peking Man

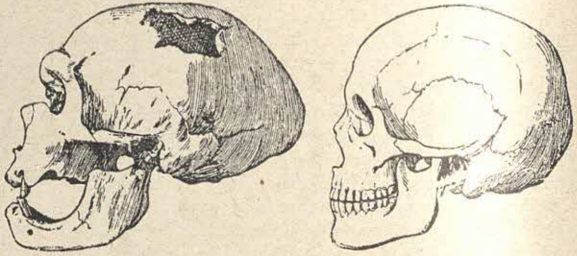
Fossil bones of the earliest men known were found in Java in 1891, other specimens in the late 1930s. Though human in many respects, these men are placed in a separate genus, *Pithecanthropus* ; they probably date from the first half of the Pleistocene, about half a million years, or more, ago. *Pithecanthropus* walked erect, but was shorter than many modern men and brutish in appearance, with a heavy jaw, prominent brow-ridges, and a very receding forehead.

At Choukoutien, near Peking, a skull was discovered in 1929, and a number of other remains since, which are now thought to be very similar to *Pithecanthropus*. These " Peking Men " are known to have fashioned tools of quartz and to have used fire. Their brains, though variable in size, were smaller than those of *Homo sapiens*. The date of Peking man is probably middle Pleistocene.

In the Pleistocene period four glaciations overspread the northern part of the world. The first glaciation probably began about 600,000 years ago, the second some 500,000 years ago. The earliest fossil remains of man in Europe are thought to date from the period between these two glaciations, but consist of a lower jaw only. This is referred to the genus *Homo*, but it is very large, and chinless ; it was found at Heidelberg in 1907, and is roughly contemporaneous with *Pithecanthropus*. Though remains of bone are so rare, roughly shaped flint instruments show that man existed in Europe, probably throughout the Pleistocene. Some bones of the roof of the skull from Kent, and two skulls from Germany, are very like those of modern man. The Kentish remains seem to date from the second interglacial period, one of the German skulls from the last interglacial period.

During the last ice age Europe and Asia were inhabited by an ape-like race of men called the Neanderthals, so named from the Neanderthal ravine near Düsseldorf, Germany. They were short individuals, with massive heads and projecting jaws. Several fossils of the Neanderthal type are known. It seems that Neanderthal man is not on the line of descent of *Homo sapiens*, but diverged from the main human stock, probably in the middle Pleistocene, and developed the ape-like characteristics of a slouching gait and heavy brow-ridges, for these are more pronounced in the later Neanderthals than in the early ones. The brain was large, though of rather a different shape from that of *Homo sapiens*. Remains of men of a Neanderthaloid type have been found in Rhodesia, in South Africa, and in Java. They are probably all late Pleistocene in date. These men are not very well known, but the skulls are too specialised for them to have been ancestral to modern man. Towards the end of the last glacial period the Neanderthal race disappeared from Europe.

The race that succeeded this Neanderthal type, the Cromagnon, were definitely of the species *Homo sapiens*. Presumably they migrated into Europe from elsewhere, and displaced the Neanderthals. They had a massive skull of high brain capacity—1,600 cu. cm. in one specimen—and exhibited that hallmark of humanity, a definite chin. They have left behind spirited drawings in the caves of France, and they were succeeded by various other cultures of modern men.



NEANDERTHAL MAN AND MODERN MAN. The Neanderthal skull (left) is so different from that of modern man (right) as to make it obvious that civilized man cannot be descended from Neanderthal man. Note the latter's shape of cranium, heavy brow-ridge, projecting jaw, and lack of chin.

LESSON 15

Embryology and Evolution

In the last five Lessons two kinds of evidence for evolution were presented. Lesson 10 showed that the great phyla of plants were built upon a common plan, and that the structure of the elaborate and higher plants was based upon that of the simpler and more lowly. In Lesson 11 similar evidence was given of the common plan and progressive evolution of the structure of animals. In Lesson 12 the evidence of fossils showed that evolution actually took this course, and that the structural features of the newer types could be traced back to the older types. The various modifications of successive animals in an evolutionary line may be regarded as a series of stages in the history of the line ; such a history is known as a *phylogeny*.

Biology is, however, also concerned with the history of the development of an individual. The life of an individual may be said to begin with the fertilized egg. The egg divides, and a hollow sphere of cells is formed—the blastula stage. This sphere doubles in on itself—as does a tennis ball when it is pushed in with the thumbs—and a double layer of cells is formed round a cup-shaped hollow, which presently becomes the gut cavity. This double-layered stage is known as the gastrula stage. A third stage is the development of the mesoderm, followed by the differentiation of the various organ systems. Further stages, such as the larval stage of the butterfly, and the tadpole stage of the amphibians, are familiar to everyone. The history of the development of an individual is termed *ontogeny*.

During the embryonic stages of the higher animals there appear features which seem to be transient repetitions of ancestral features. For example, all the lower Primates, the gibbon and the orang-utan, have nine wrist bones, whereas man, chimpanzee, and gorilla have only eight. But during the foetal stage of man this ninth bone appears as a cartilaginous nodule, which usually fuses later with the navicular bone, but occasionally persists until the adult stage.

Haeckel's Theory

Ernst Heinrich Haeckel (1834–1919), a German biologist, considered that ontogeny (the development of the individual) is a short and rapid version of the ancestral history or phylogeny. He said :

> The individual, during its short and rapid development, repeats the most important form changes which its ancestors traversed during the long and slow course of their palaeontological evolution, and each stage of ontogeny had its counterpart in some ancestral form.

Thus the fertilized egg is considered to be a repetition of unicellular organisms, the blastula repeats the cell community, and the gastrula stage has its counterpart in the Coelentera phylum. It is suggested that in some way the phylogeny is the cause of ontogeny. Haeckel's theory is now so generally discredited that it is not necessary here to produce the evidence used to refute it. It is mentioned for its historical interest only.

Von Baer's Theory

Von Baer, a Russian embryologist who preceded Haeckel by about 50 years, took the opposite view, i.e. he stressed the prior influence of ontogeny upon phylogeny. He laid down the following laws : (1) In development from the egg, the general characters appear before the special characters ; (2) embryos of any given form, instead of passing through the stages which characterise other definite forms, increasingly diverge from them ; (3) the embryo of a higher animal does not resemble the adult of another animal but only its embryo.

Thus the gill slits, or gill pouches, which appear in the embryonic stages of reptiles, birds, and mammals, do not resemble the gill slits of an adult fish, but they are very like the gill pouches which appear in the embryonic stages of fishes. The fish retains and elaborates these gill pouches ; birds and mammals convert them into other structures, such as the Eustachian tube of the ear. *Portunion*, a crustacean belonging to the order of Isopoda, is, in its adult stage, a parasite of crabs. The larval stage of this parasite resembles that of other non-parasitic isopods, and in both cases there are seven pairs of limbs on the thorax. But the normal isopods have eight pairs of limbs when adult, while the parasite loses its limbs. Thus the larva resembles the larva of its ancestors (normal isopods) and not the adult. There is no recapitulation of phylogeny.

Heterochrony

The term *heterochrony* is applied to any alteration of the sequence of stages during ontogeny. Thus, a character which formerly appeared early in ontogeny may come to appear late, perhaps so late that it never develops beyond a vestige. Conversely, other characters may appear in ontogeny earlier than before. It was shown in Lesson 9 that the genes produced variations when the chromosomes " crossed over " ; further, that mutations appeared and persisted when some change took place in the genes themselves. After the germ cell is fertilized the cell divides, and several generations of cells are required to produce the body of a higher animal. During these cell generations the genes, together with external factors, are playing their part in the successive stages of development.

Effects of Heterochrony

Genes may act at any stage of the life-history, from the fertilized egg to the production of the next generation of gametes. It is now known that genes may vary, not only in the kind of effect that they produce but also in the speed and intensity with which they produce that effect.

Mammals which have juvenile coat-patterns differing from those of the adults provide examples of genetic factors which act fairly late in the life-history. The genes controlling the adult coat-pattern do not take effect in the young animals. For instance, Siamese cats are born white, and the fur does not darken until later. (There is a second effect here, in that more pigment is produced in cooler conditions, so that the ears, paws, and tail are darker than the rest of the body.)

Genes work at varying rates, and the structure of the resulting organism varies with the rate at which they work. There is therefore a genetic basis for heterochrony.

Evolutionary Change

Some of the most striking features of evolutionary change are attributed to heterochrony. There are many cases where features present only in the young stages of the ancestor appear in the adult stage of the descendant. It should be pointed out here that most animals cease developing when the gonads are matured, that is, when the animal is able to reproduce. From this stage the animal is adult. The time at which the adult stage is reached depends upon the rate of speed at which the genes which control the development of the gonads work. It is possible, therefore, for the genes responsible for the formation of the gonads to do their work at a faster rate than do the genes responsible for some other feature of the animal's body. In this case the animal would become sexually mature while another part of its body would still be in the young or developing stage. This phenomenon is known as *neoteny.*

Neoteny

A neotenous condition will also be brought about if, while the rate of development of the gonads is not increased, there is a relative retardation in the development of other features. This process seems to have occurred in the evolution of mankind. Many features in the adult structure of man show marked resemblance to embryonic features of apes. For example, the hairlessness of the body, the relatively heavy brain, the position of the opening (*foramen magnum*) at the base of the skull, and the retarded closure of the sutures of the skull, may all be regarded as due to the occurrence of neoteny in the early ancestry of man. In other words, these features are present in adult man owing to the relative retardation of some of the somatic (body) cells compared with the normal growth of the gonads (reproductive cells) during the ontogenetic stages of man's ancestors.

In the embryonic stage of all mammals (and we may go still lower down the scale and include nearly all vertebrates) the line from the nose to the back of the head is at right angles to the backbone. During the embryonic development of animals this angle is straightened till the animal's head points in a line with the backbone. In man alone is the angle retained, so that man's line of sight is forward and at right angles to his backbone. Owing to this neotenous position the skull is balanced on the spine, and the foramen magnum (the opening at the base of the skull through which the spinal cord enters) retains the embryonic position which in other mammals, and presumably in man's ancestors, was only temporary. The brow-ridges, which are a very prominent feature of early human and simian skulls, are also absent in modern man and the embryo ape.

Evolution of Man

In comparison with other mammals, the speed of the development of the body is slow in man. Man takes, for instance, nine months to reach 7½ lb. in weight, and 180 days to double this weight, while the ox weighs 88 lb. at nine months, and doubles this weight in 47 days. In the apes, the milk teeth are cut directly after birth, and the first molar soon after the second pre-molar. The milk teeth are then replaced by permanent teeth, and the second and third molars appear at the same time. In man, the set of milk teeth is not complete till the end of two years. There is then a pause until the fifth or sixth year, when the first molar is cut. Then follows the replacement of the milk teeth, and, after that, the second molar appears, but the third molar is so retarded that it may be cut quite late in life ; often it does not appear at all. Man's long juvenile period allows time for the prolonged education of the individual which is of such importance in human cultures.

LESSON 16

Vestigial Structures

In the bodies of many of the higher animals are found structures that appear to be quite useless to their owner, but which resemble the organs of some other animal. The splint bones of the horse's leg (*see* Lesson 13) are almost useless to the modern horse, but they recall the toes of the horse's ancestors ; the whale shows its descent from a land animal in the vestigial bones of the hip girdle. Again, in the embryos of the whale-bone whale and in the baby duck-billed platypus small teeth are formed, although the adults are toothless. These embryonic teeth correspond to the teeth developed in the embryonic state in other mammals. The vestige of the hip girdle is present in some of the larger snakes (Pythonidae), and also the vestige of a hind limb—relics of the lizard-like ancestors of the snakes. Many flightless insects show vestigial wing structures, and fishes living in underground lakes may have vestigial eyes.

Vestigial structures also occur in the plant world. The desert cactus has developed leathery outgrowths from the stem, so that the sun can act upon the chlorophyll without occasioning much loss of water ; vestiges of *true* leaves, however, still appear on the plant.

Anatomists have discovered in the body of man nearly 200 vestigial organs. Many features which occur in the human embryo are merely temporary structures which disappear during ontogeny, but others persist into the adult stage, although they serve no useful purpose. The presence of these useless relics can be explained on no other assumption than that the human body has evolved from other organisms which led a different life and required a different structure to cope with their environment.

One of the most striking vestiges in the human embryo is the presence from the fourth to the eighth week of an external tail, containing from eight to eleven vertebrae. These vertebrae are progressively reduced and, as growth continues, the surrounding parts cover the tail tip. In a new-born child there is always a depression at the bottom of the back which indicates where the tail receded and was bent under. In a few instances these caudal bones have not receded, and a child has been born with a tail. Most vertebrates have tails ; primitively it was an important locomotor organ. With the adoption of an erect posture, however, a tail would be in the way, and it has been reduced in the apes and in man.

At the top of the human shoulder blade there is the hook-like, bony structure known as the coracoid (crow's beak) process. It is the vestige of a bone which, in the Australian duck-billed platypus and most non-mammalian vertebrates, forms an important part of the shoulder-girdle.

There are numerous vestigial muscles in the human body. Monkeys and lower mammals have muscles with which they can twitch and pivot the ear ; these muscles, though present, do not function in anthropoid apes and man.

The hair on the human body is useless to-day as a warmth-retaining covering, but the muscles which, in the furry animals, raise the fur on a cold day to prevent loss of heat still contract the skin into a goose-flesh state. Another vestige in man is the third eyelid—a fleshy fold in the inner corner of the eye. A cat cleans its eyeball by rapidly drawing this lid across it and back, but in man this fold is useless.

Referring back to the theory of heterochrony (described in Lesson 15), the persistence of these vestiges may be explained as a negative result of neoteny. In neoteny, it will be remembered, the somatic cells develop at a relatively slower rate than the gametic and, therefore, the body becomes sexually mature before all the embryonic features have fully developed, while some features which appeared only in the larval or embryonic stage of the ancestor appear in the adult stage of the descendant.

Vestiges Due to Retardation

The original adult features, that is, those appearing in the adult stage of the ancestor, appear too late to be fully formed by the time the descendant reaches sexual maturity. They tend, therefore, to be pushed off, as it were, from the end of the ontogeny, and, if they appear at all in the adult descendant, they appear as vestigial features. Characters, then, become vestigial owing to the relative retardation of the factors which control them. The third molar, or wisdom tooth, for example, is very late in its appearance in man ; indeed, it often does not appear.

LESSON 17

Lamarck's Theory of Evolution

So overwhelming is the accumulated evidence for evolution that it is commonly accepted as a fact to-day. This acceptance immediately provokes the inquiry why and how there arose the vast diversity of organisms that exist to-day and have existed in the past. Mendelian inheritance produces variations of existing types, but does not give rise to new characters.

Jean Baptiste Lamarck (1744–1829), a French zoologist, held a post at the Paris Museum of Natural History during the years of the French Revolution. In his day the current belief was that the different species of organisms were created once and for all, and that no changes had occurred since the beginning of the universe, though some thinkers, e.g. Kant, Goethe, and Buffon, had questioned this belief. Lamarck, in classifying the animal kingdom, was struck by the infinite gradations of forms. He declared in his *Zoological Philosophy* that life arose spontaneously in the most elementary forms, and that these forms evolved into forms of greater and greater complexity. He recognized, too, the probability of the common origin of animals and man, but, possibly in deference to the prejudices of his age, did not proclaim it.

Lamarck considered that there were two causes of evolution : the first, the fact that organisms possessed an innate tendency to evolve towards greater complexity ; the second, the inheritance of acquired characters. The following are some of the examples taken by Lamarck to illustrate his theory. Birds have acquired webbed feet by their constant effort to swim ; others (the waders), their long necks and legs by their efforts to reach their submerged food without wetting their bodies. Giraffes have long necks because ancestral giraffes, in time of dearth of low-growing food plants, stretched their necks to browse upon trees, and so, it must be supposed, each extra millimetre of neck so acquired was inherited by the descendant.

This theory of the inheritance of acquired characters has exercised the minds of biologists and other thinkers from Lamarck's day to this. It has been violently attacked by some, and as strongly upheld by others. It is an attractive theory, since, if it be true, efforts at social advancement could affect not only the present generation but its descendants. Moreover, like many other biological theories, it appears to explain how evolution occurred. But to gain acceptance it must be capable of proof, and proof is exceedingly difficult to obtain. Here are some of the objections to which the theory is exposed. In the first place, a large number of acquired characters are obviously not inherited. There is no evidence that the juggler's manual dexterity is handed on to his children, or that a baby of French lineage brought up in England is slower at learning to speak English or quicker at learning French than the average English child. Modifications of the body due to environment or to the use or disuse of some particular organ affect the body or somatic cells. Weismann pointed out that the hereditary factors or, as they are now called, the chromosomes and genes, are screened from the influences that affect the rest of the body. Therefore, characters acquired during the life of the individual would not affect the genes.

Many experiments have been conducted with a view to proving or disproving Lamarck's theory, with inconclusive or negative results. The examples which were cited by Lamarck as proof of his theory are not convincing.

The ancestors of the wading birds, for instance, must have been very persistent in the search for a fish diet to have sought it in vain for thousands of years, while they were developing their long legs and necks and their spreading toes.

The evolution of web-footed birds, the long-necked giraffe, and so on, can be better explained by the theory of natural selection, which is the subject of the next Lesson. Most modern biologists consider, therefore, that Lamarck's theory, ingenious though it is, has not been established as fact.

LESSON 18

Darwin's Theory of Natural Selection

LAMARCK published his *Zoological Philosophy* in 1809, but most scientists of his day, notably Georges Cuvier (1769–1832), refused to entertain the idea that species had evolved, and it was not until after *The Origin of Species* was published by Charles Darwin in 1859 that the idea of evolution met with wide acceptance. Evolutionary hypotheses of various sorts had been proposed before, even as early as the 6th century B.C., and by Aristotle, and incidentally by Darwin's own grandfather, Erasmus Darwin (1731–1802). It has already been mentioned that Alfred Russel Wallace came to the same conclusions as Charles Darwin at about the same time.

Fecundity and Variability

Darwin's great contribution was to suggest a mechanism by which evolution could proceed, and to back this suggestion with a wealth of observed, detailed evidence. The theory of natural selection, which Darwin expounds in *The Origin of Species*, arose from the consideration of two facts. The first of these is the amazing fecundity of life, every species producing more individuals than survive ; the second, the universal variability of life.

With regard to the first point, it has been calculated that the one-celled *Paramoecium* (a protozoa : *see* Lesson 5) alone would, in a few years, fill the known universe with its offspring, if they all survived and continued their geometrical rate of reproduction. The second is equally obvious : no two plants or two animals are exactly alike ; variation is especially obvious in many domestic animals and cultivated plants. Since, then, the large majority of individuals perish in the struggle for existence, the minority which survive will be those most fitted and adapted to their environment. These individuals are endowed with favourable variations in virtue of which they survive. Although the variations may be slight, they will be handed on to the next generation, in which there will be further accentuation of these variations, and so on. A new species appears when a sufficient number of variations have accumulated.

Selective Breeding

The gardener and the animal breeder produce wide variations by selecting parents which show some of the characters they are anxious to develop, and then, from the descendants of these parents, again selecting for mating those individuals which possess the required characters in the fullest degree. In this way, for example, animals as diverse as the carthorse and the racehorse (or as the greyhound, bulldog, and King Charles spaniel) have been produced from what is probably the same original stock. Natural selection, in the same way, eliminates those organisms which are not best fitted for survival. Darwin suggested, for instance, that the colour of grouse resembles that of their background because hawks are more liable to prey on those whose colour does not match the background.

Selection or Disuse

Some modifications in structure which would be attributed by Lamarckians to the inheritance of the acquired effects of disuse are explained more simply by the theory of natural selection. More than 200 species of beetle on the island of Madeira are wingless or have only vestigial wings ; they also have the habit of sheltering under stones, etc., during a storm. These facts might well be attributed, as in Lamarck's view, to inheritance of a character acquired through disuse ; but Darwin pointed out that many species of beetles which depend on their wings for their livelihood and which flourish elsewhere are absent from those islands. He suggests that the wingless state of so many beetles is due to the fact that for generations beetles which flew least, through indolence or wing deficiency, would have the best chance of survival in a storm, as they would not be blown out to sea. Their wing deficiency (caused, as is now known, by gene mutation) or indolent habit would be inherited, and natural selection would continue to favour those of weak flying habit. This is an interesting example of the survival value that may sometimes result from the loss of organs.

Darwin's theory also explains the occurrence of the phenomenon of mimicry in plants and animals. The stick insect can scarcely be distinguished from a dead twig. Harmless flies (Syrphidae) have the significant coloration of the bee or wasp, and are left alone by the insect-eaters in consequence. An Australian fish (*Phyllopteryx*, cousin to the sea-horse) has appendages of ragged skin which enable it to sidle up to its prey, or to escape from its enemies, in the guise of seaweed.

Value of Mimicry

The green tree-frog, the striped zebra and tiger, the twig-like caterpillars, the poisonless snakes which have the same markings as the poisonous adder and cobra, are all examples of the survival value of mimicry. To test the protective value of colour, 45 green praying mantises (insects) were tethered to green herbage, and 65 of a brown-coloured variety to brown, withered grass. At the end of 17 days all had survived. But when 25 green insects were tethered to brown herbage, all were eaten by birds in 11 days ; of 45 brown insects tethered to green grass, only 10 survived after 17 days.

But to return to Darwin. *The Origin of Species* was not his first work; he had previously written books on coral islands and on barnacles, for instance, which were of considerable importance. Later he published works on the varieties of animals and plants produced by domestication, and on sexual selection, and other topics, but his later work is not as well known as *The Origin of Species*.

Darwin's Sports

Darwin knew nothing of Mendelian inheritance or of the modern discoveries of chromosomes and genes. In particular, the evidence which modern biologists are accumulating to show that the causes of variation must be located in the genes was denied to him. Indeed, he dismissed sudden and large variations as " sports " and of no significance. To-day these variations caused by transmutation of chromosomes are seen as the basis of evolutionary development. What Darwin did was to insist that all inherited variations are tested and must, in order to survive, pass through the sieve of natural selection. It has already been mentioned that sexual reproduction is of importance in evolution in permitting the recombination of hereditary factors, so bringing about variation. It is important to remember that it is not individuals which evolve, but populations. Favourable variations will be selected and will spread throughout a population and so, eventually, may become characteristic of an entire species. Alternatively, populations which do not interbreed with one another may evolve in different ways and so form two species.

LESSON 19

Environment's Part in Evolution

LIFE, as it is known to us, can exist only within a relatively narrow environment. The temperature must be within a certain range ; there must be available water, and appropriate gases, and nutritive substances. Given these essential conditions, the nature of the environment will be one of the chief factors operating in natural selection. Those animals best adapted to their particular environment will have most chance of surviving and leaving descendants. The existence of different types of environments will allow the development of various kinds of animals and plants. The effect of climate is familiar ; there are wide differences in the flora and fauna of, say, the arctic regions and the tropics.

One of the most striking effects of environment on evolution is to be found in island life. In Lesson 18 the wingless insects of Madeira were cited ; on some islands it is not only the insects but the birds which have lost the power of flight. Galapagos has a flightless cormorant ; in New Zealand are the kiwi and a flightless owl-parrot. In prehistoric times the moa, a giant flightless form, also existed in New Zealand. Species of flightless birds, notably marsh rails, live in the South Sea Islands. The dodo was a large flightless pigeon which inhabited Mauritius until it was exterminated by man towards the end of the 17th century. These islands were cut off from the mainland before the mammalian beasts of prey had spread to them, and in this isolation flight was not a necessity. New species are particularly liable to arise on islands, because not only is there less competition but also the population is isolated and cannot interbreed with neighbouring populations.

Another striking result of environment is seen in the cave-dwelling animals. In the Mammoth Cave of Kentucky fishes occur in various stages of bleaching and eye degeneration. A newt, *Proteus*, lives in the limestone caves of the eastern Alps ; it is blind, and pinkish-white, with vestigial legs. These acquired characters have not been transmitted in the Lamarckian sense. If a young *Proteus* is exposed to light, it develops a dark pigmented skin. Hence it possesses the genes for pigment formation, but its environment has overshadowed its heredity.

Heredity or Environment

The relative importance of these two factors —heredity and environment—is often difficult to decide in any one case. On this point the study of identical twins is instructive. Ordinary or " fraternal " twins are produced because two eggs have been fertilized at the same time ; but it may happen that a single egg produces two embryos, identical twins, formed from the same set of chromosomes and genes. Such twins are always of the same sex. It is assumed that since their heredity is the same, any difference between identical twins will be the effect of environment.

Environment is capable of altering the expression of heredity, though as far as is known such acquired characters are not inherited. Stature, for instance, will depend both on the genetic make-up of the individual and on the amount of nutriment available. Red deer, taken from the Scottish Highlands to New Zealand, grew to a larger size, simply because there was more food available. The Scottish deer had been under-nourished and so never attained their potential full size. The fatness of pigs can be affected according to whether they are given plenty of food when young and growing rapidly or when they are older. The milk yield of cows can be similarly affected by factors other than genetic ones. These things have to be taken into consideration when breeding. The environment is also of obvious importance in that the nature of the environment determines what sort of selection will take place in nature.

The importance of the environment in these and other ways has led some biologists to cling to the idea that some acquired characters may in some way be inherited, though not perhaps in the crude way which Lamarck envisaged. These biologists form what is known as the Neo-Lamarckist school.

However, since the experimental evidence points the other way, and most of the facts can be adequately explained on a theory of selection acting on variations produced by mutations, the majority of biologists at the present time reject the Neo-Lamarckist view.

LESSON 20

Some Practical Uses of Biology

THE first attempts at agriculture by prehistoric man included wheat growing. Wheat grains have been found in rubbish heaps left by the lake-dwellers of Italy and Switzerland, and in the bricks of an Egyptian pyramid dating from about 5,000 years ago. All the ancient civilizations used wheat as a staple food, the Greeks and Romans considering it to be a gift from the gods. Wild wheat, from which all modern varieties have descended, has been found growing on the slopes of Mount Hermon, in Syria. The Roman agriculturist experienced the same difficulty as that which beset our own farmers up to the present century, namely, that cultivated wheat was liable to be attacked by rust, a fungus disease. On April 25 every year the Romans held a feast to propitiate by sacrifice the rust-god Robigus.

Wheat-Growing

As soon as the significance of Mendel's laws was realized, one of the first practical applications was the endeavour to improve the quality of wheat. The ideal wheat was to be glutinous, hard, high-yielding, and rust-resisting. Sir Rowland Biffen (died 1949) crossed a low-yielding, rust-resisting wheat with a high-yielding variety which was not immune from the disease. The experiment turned out in accordance with the Mendelian table shown in the diagram in Lesson 7. All F_1 were infected, but in F_2 some plants were homozygous both for rust-resisting and for high yield ; that is, in the general re-shuffling of genes by the self-fertilization of F_1, a double dose of rust-resisting and high-yielding genes met in some plants, and these alone were selected for future propagation. The result has been a high-yielding wheat immune from rust.

Canada has its special problems in wheat growing. A wheat that ripens five or six days earlier than other varieties may enable the farmer to make a profit instead of a heavy loss. The harvest escapes the frost, which in the northern districts sets in about August 20, and the farmer has a few days to clear the land before the " freeze up." Further, the heavy storms to which the wheat lands of Canada are subjected make it desirable for the wheat to have a stout, pliant straw and an ear from which the grains are not easily scattered. The Marquis wheat, which nearly fulfils these conditions, is grown over vast areas in America and Asia. By crossing this variety with others, a Russian geneticist succeeded in identifying the six pairs of genes which produce the distinctive characters, the peculiar broad-shaped grains and glumes, of the Marquis wheat.

Duplication of Chromosomes

A frequent occurrence in the reproduction of plants is the duplication of entire sets of chromosomes. In Lesson 5 the normal cell was described as diploid—that is to say, it has a double set of chromosomes—but after meiosis has taken place the gametic cells are usually haploid, having only a single set. It occasionally happens in plants, less frequently in animals, that for some reason not yet known the cell division stops half-way, and, instead of two haploid gametic cells, the original gametic cell remains with a double number of chromosomes. If the plant is self-fertilizing, the progeny also has a double number of chromosomes. In the result all the characters are affected ; the cells are much enlarged, and the plant, although identical in character with its parent, is itself larger. The extra growth of many cultivated garden plants is due to the fact that they are tetraploids : that is to say, each somatic cell, instead of a double set, has four sets of chromosomes. The common evening primrose has 14 chromosomes, while a giant variety has 28 in each somatic cell.

Three Sets of Chromosomes

A third type of plant (triploid) is produced by crossing a diploid with a tetraploid. If a gamete from a tetraploid is fertilized by a gamete from a diploid, there will be a fusion of two sets of chromosomes from the tetraploid plant with one set from the diploid ; the result is a triploid individual with three sets. Most of these triploid plants are sterile, since odd numbers of sets of chromosomes form gametes with unequal numbers of chromosomes and complete pairing is impossible.

Roses, lilies, tulips, and daffodils are triploid or tetraploid. Wild wheat has 14 chromosomes; many of the best-yielding cultivated varieties have 42. Hexaploid and octoploid plants can be formed by further crossing.

The science of genetics has been limited, for the most part, to the experimental study of the genetics of inexpensive, quick-maturing, and highly fecund types, such as fruit-flies, moths, rabbits, guinea-pigs, mice, and rats. Moreover, the science of genetics is faced with a much more difficult problem in dealing with the animal world than that which is presented by plants. This problem arises from the fact that there is no self-fertilizing animal, and pure line experimental breeding is therefore impossible, though " pure-lines " in the sense of lines restricted to brother-sister matings can be maintained in some cases. Nor can useful but sterile hybrids such as the mule be perpetuated by grafting, as is done with plants. Nevertheless, much analytical work has been done which explains the difficulties and disappointments of the practical breeder, even if it does not yet show him how to overcome them. The science of genetics has also cleared away many superstitions that impeded the art of practical breeding.

Genetics and Man

It has been suggested that knowledge of genetics can be applied in improving human stocks, which, it is assumed, are no longer kept automatically efficient by the action of natural selection when men live in civilizations. However, as man breeds very slowly, knowledge about his genetics is difficult to obtain ; though this ignorance can be overcome in time, the practical application of the knowledge gained would be even more difficult, apart from any moral or political objections to such a course. Many of the human characteristics which are of interest from this point of view may not be inherited, or, if they are, may be due to so many heritable factors that their analysis and manipulation would be impossible. On the whole, then, eugenics (the physical improvement of the human race by breeding) is less used to-day than it was. In any case natural selection can only be cushioned by civilization, not prevented.

Other and more urgent problems have arisen lately. The history of man has been marked by several sudden increases in total population. It is thought that one such increase occurred with the first development of agriculture in Neolithic times, after the last Ice Age. The Industrial Revolution (18th–19th century) was accompanied by another great increase in population, and the modern development of medical science (itself, incidentally, an application of Biology) has led to another. Since the available food supply is limited, it is very possible for the population of the earth to become too big.

Improving Food Supplies

Biology can be of great help in improving existing food supplies, and perhaps in exploiting new ones, or in seeing that old ones are not over-exploited.

The last case applies especially to the fishing industry ; fish populations can be depleted by overfishing ; but by proper knowledge of the habits and life histories of the food fishes overfishing can be avoided and this source of food maintained. The same applies to whales, which are in danger of extermination unless international control is applied.

The medical applications of biology, previously mentioned, include not only the knowledge of the functioning of the body which is of direct use in medicine and surgery but also the control of diseases which are spread by animals. For instance, bubonic plague is a disease of rats, spread by fleas; it can be prevented from spreading by attacking the animal vectors ("carriers"). Similarly, malaria has been eradicated from vast areas by draining the areas of water in which mosquitoes breed, or by covering them with oil so that the mosquito larvae cannot breathe. There are other examples. Pests of plants can be controlled either directly, or by introducing animals which are predators on the pests; but this method is apt to misfire, as it may in turn prove difficult to control the predators.

To return to human populations, apart from increasing the food supply, other contributions which biology may make to the problem, perhaps indirectly, include the discovery of simple and effective methods of birth control, so that the size of populations can be limited voluntarily before they get too big. A study of animal behaviour may perhaps prove an aid to the study of human behaviour; understanding is the first step towards control. It has become apparent in recent years that if man, with the resources of modern science at his disposal, continues to behave in his accustomed ways, disaster is imminent. The remedy lies not in the attempted restriction of science but in the application of scientific method in solving the new problems that have arisen and the old problems that have acquired new urgency.

BOOK LIST

Reference should be made also to the Courses on **Botany** and **Zoology**

General. *The Science of Life*, H. G. Wells, J. S. Huxley, and G. P. Wells (Cassell); *Biology in Everyday Life*, J. Baker and J. B. S. Haldane (Allen and Unwin); *Animal Biology*, J. B. S. Haldane and J. S. Huxley (Oxford).

Micro-organisms, etc. *The Physical Basis of Life*, J. D. Bernal (Routledge and Kegan Paul); *Introductory Study of Protozoa*, E. A. Minchin (Arnold); *Viruses and Man*, F. M. Burnet (Penguin).

Plant Life. *An Introduction to the Structure and Reproduction of Plants*, F. E. Fritsch and C. J. Salisbury (Bell); *Plant Physiology*, M. Thomas (Churchill); *The Fertilization of Orchids*, C. Darwin (Murray); *Plant Life through the Ages*, A. C. Seward (C.U.P.).

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Genetics. The relevant portions in *Butterflies*, and *Moths*, E. B. Ford (Collins).

World Food Problems. *Feeding the Human Family*, F. Le Gros Clark (Sigma); *Four Thousand Million Mouths*, Ed. by F. Le Gros Clark and N. W. Pirie (O.U.P.); *The Inexhaustible Sea*, H. Daniel and F. Minot (Macdonald); *The Fish Gate*, M. Graham (Faber and Faber).

CHEMISTRY

THIS *Course is not only an elementary textbook of Chemistry which reaches a standard satisfactory to most non-specialist students but it is also a treatise which will be read with keen appreciation by others with interests in scientific subjects.*

Its scope includes the principles and practice of Inorganic Chemistry, an up-to-date treatment of the problems of Physical Chemistry, and the Chemistry of the Organic Compounds of Carbon.

For a purely physical discussion of the modern theory of the structure of the atom the student should refer to the Course on PHYSICS *in Vol. 2.*

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LESSON 1

Elements and Compounds

It was Robert Boyle (1627–91), an Irish chemist, who first recognized the fundamental unit of chemistry, the element, and so laid the foundations upon which chemical theory has been built. The Greek philosophers had held that all substances had resulted from the union of air, earth, fire, and water, and this theory had given way to that of the alchemists who thought that all substances were combinations of mercury, salt, or sulphur.

Until 1661, when Boyle published his criticism of these theories, there had been no systematic experimental chemistry, and men's minds were obsessed with the search for the "philosopher's stone" with which it was thought baser metals could be transmuted into gold. Robert Boyle for the first time established chemistry as a separate science and he classified all substances into two groups: elements, which were unique and could not be broken down into simple substances; and compounds, which were composed of two or more elements.

In 1774 a Frenchman, Antoine Lavoisier (1743–94), combining the results of an Englishman, Joseph Priestley (1733–1804), proved that air was not an element but a mixture of two gases, now called oxygen and nitrogen, and true research into chemistry had begun.

Search for Elements

Since Lavoisier's discoveries the quest for new elements has gone on steadily, and 99 elements have been identified. As will be seen in the discussion of the periodic table, when these elements are arranged in order of increasing atomic weights they exhibit well-defined chemical relationships. Investigations of atomic structure have shown that these relationships are the result of structural characteristics which are defined by the atomic numbers of the elements when placed in order. In the periodic table there were formerly spaces for 92 elements occurring in nature, beginning with hydrogen, the lightest, and ending with uranium, the heaviest. Two elements had not been identified. With the advent of the atomic pile, seven new elements have been created, called the transuranium series, and the two unknown elements in the periodic table have been identified.

Advances in atomic chemistry necessitate a widening of the definition of an element as "a substance which consists of only one kind of matter and cannot be subdivided." It is now known that the atoms of elements are in fact composed of even smaller units carrying electrical charges, but since these charges are too binding to be broken by chemical means the atom can still be regarded as the basic unit in the structure of matter. An element is now defined as "a substance in which all the atoms have the same atomic number."

Substances which are not elements may be classified as *mixtures* or *compounds*. In general, it can be said that mixtures appear to be heterogeneous to the eye or to the microscope and their constituent substances may be separated by simple mechanical processes. On the other hand, compounds are always homogeneous and no amount of physical subdivision will effect a separation of the constituents of a compound. Thus, a mixture of iron filings and sulphur can be readily separated either by removing the iron by a magnet or by dissolving the sulphur in a solvent such as carbon disulphide. But if these two elements are heated together to form the compound, iron sulphide, no such methods of separation can be applied.

Chemical Mixtures and Compounds

Moreover, the properties of a mixture represent the sum of the specific properties of the various substances from which it is made up, while the properties of a compound are usually unique and completely different from those of the elements of which it is composed. A mixture of nitrogen and oxygen is colourless and physiologically harmless—in fact, it is the air we breathe; but one compound of these two substances is a brown, poisonous gas.

Mixtures are, in general, produced without any change in energy; no rise in temperature is experienced when artificial air is made, as by Lavoisier, by mixing the required amounts of oxygen and nitrogen. The formation of a chemical compound, however, is usually attended by a chemical change involving a gain or loss of energy in the form of heat and light.

Chemical and Physical Changes

It is important to notice in this connexion that when a piece of iron is heated it glows strongly, i.e. it emits heat and light so that the heating of iron might possibly be regarded as a chemical change. Actually this is not so, since the iron reverts to the initial state on cooling; its properties are the same before and after the process of heating. Similarly, when water freezes or is boiled to steam some of its properties change and it might be assumed to have undergone a chemical change. Examination shows, however, that only its physical or arbitrary properties have changed, while its specific or chemical properties have remained unaltered. It is thus said to have undergone a physical and not a chemical change, although a slight energy change has taken place in the process of freezing or boiling.

Considerable importance attaches to this question of the energy interchange which takes place during a chemical process, since the chemist is able, from measurements of the amount of energy involved, to make inferences as to the chemical nature of substances and their probable modes of reaction.

Careful examinations of the transformation of one form of energy into another gave rise to the law of conservation of energy—*the amount of energy contained within a sealed system is constant and unalterable*, so that if the energy evolved as heat and light during a chemical change can be measured it is possible to estimate the amount of chemical energy associated with the substances taking part in the reaction. It may be asked in such a case—whence comes the so-called chemical energy ? The answer to this question is contained in our Lesson on atomic structure. Suffice to say here that associated with unit quantities of all forms of matter are definite amounts of energy which enable them to react chemically under the right conditions.

LESSON 2

The Physical Properties of Gases

THE quantitative facts of chemistry can be explained only on the assumption of a discontinuous structure of matter. All substances—whether in the solid, liquid, or gaseous state—are composed of a definite number of minute incompressible particles or molecules, which are separated from one another by space. In gases, the volume actually occupied by the molecules is small compared with the free space, since gases in general have a small density and can be compressed easily.

Liquids, on the other hand, are much denser and have only a slight compressibility, so that the free space between the molecules is much more restricted ; solids are still more compact. In general, it can be said that by a suitable change of the condition of temperature and pressure any substance can be converted from one state of aggregation into another. For example, under atmospheric pressure solid ice is converted into liquid water at a temperature above 0° C. and into gaseous steam above 100° C. Similarly, carbon dioxide gas may be converted into a liquid at $-78°$ C. and a solid at lower temperatures. Providing a sufficiently low temperature be attained, all gases can be liquefied, and for those less condensable a high pressure is also necessary.

Brownian Movement

In 1827 the Scottish botanist Robert Brown (1773–1858) noticed that when the fine particles of lycopodium powder suspended in water were examined under the microscope they appeared to be in an incessant state of violent and erratic motion. Sir William Ramsay (1852–1916) suggested that this was due to the continual bombardment of the particles by the molecules of the liquid. More recently the French physicist Jean Perrin (1870–1942) and his co-workers showed that the minute particles present in a colloidal solution also exhibit this Brownian movement, and from investigations of the properties of colloids Perrin was able to prove that Ramsay's explanation was correct.

It had long been known that in a gas the molecules, as a result of processes such as diffusion, are in a constant state of rapid motion, being hindered in their progress to and fro by the collisions which they encounter with other molecules. The work of Brown and Perrin showed that a similar state of affairs exists in liquids, though, owing to the more compact nature of a liquid and the greater probability of collisions between molecules, the motion of the molecules is more restricted.

Kinetic Theory of Matter

Similarly, it is now believed that in a solid the molecules are in a state of constant agitation, though because of their nearness to one another, the forces of cohesion are greater than in the other two cases. Thus the molecules are not able to move freely to and fro, but exist in a state of vibration about some mean position. Because heat energy can be readily converted into other forms of energy, such as energy of motion, or kinetic energy, the energy of motion of the molecules is increased when a solid is heated. If sufficient heat is supplied, the kinetic energy becomes greater than the forces of cohesion between the molecules, and the solid becomes first a liquid and finally a gas.

In a gas the forces of cohesion are very small and the molecules are hindered in their motion only by collisions with other molecules or with the walls of the containing vessel.

Boyle's Law

When each molecule strikes the wall it experiences a change in momentum, and it is the sum of these changes imparted to the walls of the vessel that constitutes the pressure exerted by the gas. If the volume occupied by the gas is compressed by, say, one half, obviously the number of collisions with the walls, and therefore the pressure of the gas, will be doubled. In general it can be said

> *that the volume of a gas varies inversely as the pressure, providing the temperature remains constant*—a law which was discovered experimentally by Robert Boyle (1661) and is known as Boyle's law.

If, on the other hand, the temperature of the gas is raised, the kinetic energy, and therefore the rate of motion of the molecules, is increased, and if the pressure is to remain constant, the volume must also increase. In other words,

> *the volume of a gas is directly proportional to the temperature, providing the pressure is constant*—a law which was verified experimentally by Jacques Charles (1746–1822).

If V_0 and V_t are the volumes of a gas at temperatures 0° C. and t° C. and α is the coefficient of expansion—i.e. the change in unit volume for unit rise in temperature—then Charles's law may be written

$$V_t = V_0 (1 + \alpha t)$$

It has been found that for most gases

$\alpha = \frac{1}{273}$, so that in the above equation, if $t = -273$° C., $V_t = 0$.

This means that at a temperature of − 273° C. there would be no spaces between the molecules, and since the size of the molecules themselves is very small, the volumes of all gases would approximate to zero. This temperature is the *absolute zero of temperature*. So far it has not been possible to reach the absolute zero, though a temperature of below − 270° has been attained. Charles's law may be written :

$$\begin{aligned} V_t &= V_0 \left(1 + \frac{1}{273}t\right) \\ &= V_0 \left(\frac{273 + t}{273}\right) \\ &= V_0 \frac{T}{T_0} \quad . \quad . \quad . \quad . \quad . \quad (1) \end{aligned}$$

$T = 273 + t$°C. absolute temperature of the gas.

From Boyle's law, if V is the volume of gas at pressure P, then

$$P = \frac{k}{V}, \text{ or } PV = k,$$

or if V_1 is the volume for another pressure P_1,

$$PV = P_1V_1 \quad . \quad . \quad . \quad . \quad (2)$$

Equations (1) and (2) may be combined thus :

$$\frac{PV}{T} = \frac{P_1V_1}{T_1}$$

which reduces to $PV = RT$ where R is a constant for all gases.

Boyle's law is also discussed under PHYSICS, and Charles's law in the same course.

The density of a gas is the weight of 1 c.c. at N.T.P. (0° C. and 760 mms. pressure). It can be obtained directly either by weighing a known volume of the gas, or indirectly, as in the Victor Meyer (1848–97) method of determination of vapour densities. One important aspect of the density of a gas is that it provides a means of calculating the molecular weight of the gaseous substance. When the Italian scientist Amadeo Avogadro (1776–1856) put forward his molecular theory he showed

> that equal volumes of all gases under the same conditions of temperature and pressure contain the same number of molecules.

Hence the relative weights of gaseous molecules can be determined by comparing the weights of equal volumes of the gases, i.e. by comparing their gaseous densities. It has been found experimentally that 1 c.c. of hydrogen at N.T.P. weighs 0·0000899 of a gram, so that 2·016 grams occupy approximately 22·4 litres. According to Avogadro's law, therefore, the molecular weight of any gas expressed in grams occupies 22·4 litres at N.T.P.

Owing to the difficulty in measuring the density of gases accurately, values of molecular weight found in this way are only approximate. The accurate molecular weight is obtained by reference to the combining weight of the element, which can be determined more exactly. It has been shown that molecular weight = m × atomic weight = mn × combining weight, where m and n are both simple integers (1, 2, 3, 4, etc.), and represent respectively the number of atoms of which each molecule is composed and the valency of the element. Thus, if the combining weight and m are known, the accurate molecular weight is the simple multiple of the combining weight which is most nearly equal to the value for the molecular weight obtained from measurements of the density.

Atomic Weight

The atomic weight of an element is, strictly speaking, the least amount of the element present in the molecular weight of all its known volatile compounds. Actually it would be far too laborious a process to obtain the atomic weight of an element by fulfilling the requirements of this statement. It is known, however, that

> atomic weight = n × combining weight, and molecular weight = m × atomic weight,

so that, as in the previous case, the atomic weight is usually calculated indirectly from a knowledge of either the combining weight or the molecular weight and the factors n and m.

In 1818 the Frenchmen Dulong and Petit found that the product of the atomic weight and the specific heat of an element is approximately a constant, and that this constant—called the *atomic heat*—has an average value of 6·4. Thus, if the specific heat of the element is known, an approximate value for its atomic weight may be calculated. In order to find the accurate atomic weight it is necessary to know the combining weight of the element. The true atomic weight is then the simple multiple of the combining weight which approximates to the value obtained from the atomic heat.

LESSON 3

The Laws of Chemical Combination

In the latter part of the 18th century Lavoisier showed that the process of combustion is due to a chemical reaction between the combustible substance and oxygen. He realized that it was quite unnecessary to invent a phlogiston—an imaginary subject with properties fundamentally different from all known forms of matter—and proceeded to demonstrate that the constituents of water and air were gases possessing mass and weight. They were, in fact, matter with the basic properties of matter.

Lavoisier roasted metallic tin in a hermetically sealed flask containing air, and found that the gain in weight of the tin, due to the formation of " tin calx," corresponded exactly to an observed loss in weight of the air in the flask. In the process of conversion of metal into calx, therefore, a certain definite amount of air was " fixed " ; and Lavoisier showed that the portion of the air fixed by calcination was the gas oxygen.

Lavoisier extended his experiments with metals to all types of combustible substances and proved that all the common phenomena of burning, and also of breathing, involved a chemical reaction with the oxygen of the air—a process now called oxidation.

Law of Conservation of Mass

In the course of his experiments on combustion Lavoisier obtained convincing proof of a great law. To quote his own words :

> *nothing is created, either in the operations of art or in those of nature, and it may be considered as a general principle that in every operation there exists an equal quantity of matter before and after the operation, that the quantity of the constituent is the same, and what happens is only changes, modifications.*

This law has been put to several searching tests, amongst which may be mentioned the experiments of the Belgian chemist Jean Setonis Stas (1813–91), who from 1860 to 1865 carried out some extraordinarily accurate syntheses of silver iodide. He found that the weight of silver iodide obtained from silver and iodine differed by less than 0·002 per cent from the sum of the weights of the elements, and so definitely proved that the Law of Conservation of Mass is one of the exact laws of science. And so, as a historian of science has succinctly stated, " the principles established by Galileo and Newton in mechanics were carried over into chemistry."

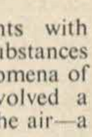


Fig. 1. Landolt's Flask.

The law can be simply verified by means of a Landolt flask (Fig. 1). This consists of two glass tubes which are joined by their necks and are sealed after chemical solutions have been introduced into each tube. The apparatus is weighed, and then the solutions are mixed to produce a chemical reaction, e.g. sodium chloride and silver nitrate solutions. On reweighing after the reaction there is no change in the weight.

It has been mentioned that the characteristic properties of a chemical compound are unique and entirely different from those of its constituent substances. The essentially distinct properties of compounds led chemists to infer (correctly) that there was a set of quantitative laws governing their formation.

Quantitative Laws of Combination

Stas in 1860 prepared silver chloride in several different ways and found that the chemical composition of each specimen was the same. Since then many compounds have been analysed, but there has been no exception to the Law of Constant Composition :

> *that the same chemical compound, irrespective of its method of formation, always contains the same elements united together in the same proportions by weight.*

With copper oxide, for example, which can be prepared in many ways, 1 gram of copper always forms 1·2517 grams of copper oxide.

The investigations of the Law of Constant Composition revealed numerous examples of two or more compounds containing the same elements combined in different ratios. The relation existing between such combinations was not discovered until 1804, when John Dalton (1766–1844) put forward the Law of Multiple Proportions :

> *If two substances A and B unite in more than one proportion, giving rise to two or more compounds, the various weights of A which combine with the fixed weight of B bear a simple numerical ratio to one another.*

It was found in the two oxides of carbon, for example, that for a fixed weight of carbon the ratio of the weight of oxygen in the compound carbon monoxide to that of oxygen in the dioxide was as 1 to 2. The best example of this law is that of the five oxides of nitrogen.

MULTIPLE PROPORTIONS LAW : NITROGEN OXIDES

Compound	Weight of Nitrogen	Weight of Oxygen combined with 14 of Nitrogen	
Nitrous Oxide	14	8	8 × 1
Nitric Oxide	14	16	8 × 2
Nitrogen Trioxide	14	24	8 × 3
Nitrogen Tetroxide	14	32	8 × 4
Nitrogen Pentoxide	14	40	8 × 5

The quantities of oxygen combined with this fixed weight of nitrogen, therefore, bear to one another the simple ratios 1 : 2 : 3 : 4 : 5.

The laws of constant composition and multiple proportions suggested the possibility of assigning to the various elements a complete series of arbitrary weights. It was necessary to choose a standard quantity of a standard element and assign to the other elements fixed values indicating the quantities of these elements which were chemically *equivalent* and therefore capable of taking part in a reaction as a chemical unit. The weights assigned to the elements were then called the "equivalent" or "combining" weights, and the Law of Combining Weights stated that

> *elements combine with each other in the ratio of their combining weights or of simple whole multiples of these.*

As hydrogen is the lightest element, it should be the standard and have the value of unity. But, as is shown in the next Lesson, hydrogen does not combine with many elements, so oxygen has been made the standard.

LESSON 4

The Atomic Theory

According to the Law of Combining or Equivalent Weights it is possible to compare the relative quantities of the elements, which are chemically equivalent to one another. Since hydrogen is the lightest element, it was chosen as standard and given the value of unity.

Unfortunately, hydrogen does not combine with many elements, so oxygen, which forms a very large number of compounds, has been constituted the standard.

In the first experiments on the combination of hydrogen and oxygen by weight it was thought that one gram of hydrogen combined with eight grams of oxygen. The combining weight of oxygen was therefore given the value of eight. More accurate determination of the ratio hydrogen to oxygen has shown that 1·008 grams of hydrogen combine with eight grams of oxygen ; but since it is more convenient to retain the oxygen standard, the value of eight has been fixed for the combining weight of oxygen.

> The equivalent or combining weight of an element is, therefore, defined as that weight which will combine with or displace eight parts by weight of oxygen or 1·008 parts by weight of hydrogen

The Law of Combining Weights offered a suitable unit to define the quantitative aspects of chemical union, but there was a difficulty in the way of accepting the combining weights of the elements as the fundamental chemical units. In the case mentioned of the five oxides of nitrogen, the weight of nitrogen which combines with eight grams of oxygen may have any of the four values, 14·7, 4·66, 3·5, and 2·8, according to the nature of the compound considered. Which of these is the fundamental unit for nitrogen ? By definition each of these four values is equally correct for the combining weight of nitrogen.

Similarly, in the case of the two oxides of carbon, the combining weight of carbon has the values of six (carbon monoxide) and three (carbon dioxide), and in the three oxides of iron, iron has the combining weights of 27·9 (ferrous oxide), 18·6 (ferric oxide) and 20·9 (magnetic iron oxide). It was this variability of the value of the combining weight which rendered it unsuitable as the chemical unit of quantity. The fundamental unit was ultimately discovered in the atomic theory of the British scientist John Dalton.

The Atom

The idea that the ultimate constituents of matter are indivisible particles called atoms was put forward by the Greek philosophers more than 2,000 years ago. According to Aristotle (384–322 B.C.) it was believed that these atoms were all composed of the same primordial elements, but the physical characteristics—size, shape, etc.—of the atoms of different substances were different. When the four-element theory of the Greeks was finally discarded and the modern concept of the elements substituted in its place, a revision of the theory of the atom became necessary. Its restatement by Dalton in 1808 gave it a definite and quantitative significance.

John Dalton accepted the view that the atoms are real discrete particles of matter, indestructible, and incapable of further subdivision; but whereas in the older theory all atoms were supposed to be composed of the same chemical substances, according to Dalton the physical and chemical properties of the atoms of any particular element, which were themselves identical, were entirely different from the properties of the atoms of any other element. A compound then was formed by the union of atoms, and since the composition of the atoms themselves was definitely fixed, the composition of the compound was also constant, giving the Law of Constant Composition. Moreover, in the case where two elements A and B united to form two or more compounds, these compounds were formed by the union of whole numbers of atoms in the proportions (A + B), (A + 2B), (2A + B), and so on. Each of these compounds had a definite composition, and

> the weights of the one element which combined with a fixed weight of the other were related by simple integral proportions. This is the Law of Multiple Proportions.

Dalton's atomic theory thus fits in with all the experimentally determined laws of chemical composition, and has become the basis of modern chemical theory.

Atomic Weights

The fundamental chemical unit is the atom, and since weight or mass is the property commonest to all forms of matter a convenient way of comparing the atoms of different elements would be to compare their relative weights. Unfortunately the atoms are far too small to be detected even under the highest-powered microscope, so that it was impossible to determine absolute values of their weights by direct weighing. But by fixing on some suitable standard it was possible to obtain the relative weights of the various atoms. Dalton gave hydrogen—the lightest element—the value of unity, and compiled a set of atomic weights of the elements. As has already been mentioned, the value for hydrogen has since been changed to 1·008, and the modern system of atomic weights has been determined on this basis.

The methods used to determine atomic weights are described in a later Lesson.

Definition of Atom and Molecule

The atomic theory had offered a satisfactory explanation of the laws of chemical combination, but there was still some confusion between the ultimate particles of an element and those of a compound. Dalton defined them as element atoms and compound atoms respectively, but since a compound can, in general, be subdivided into its constituent atoms, and an atom is chemically indivisible, the term compound atom had very little meaning. This inconsistency was cleared up by the Italian physicist Amadeo Avogadro (1776–1856), who in 1811 defined the smallest particle of a compound as a molecule. An atom, then, is defined as the smallest particle of an element which can take part in a chemical reaction, and a molecule is the smallest particle of a substance—either an element or a compound—which can exist in the free state. In the case of an element all the atoms composing the molecule must naturally be similar, but the number may vary from substance to substance.

Molecular Hypothesis

For example, the molecules of the rare gases, which have no power of chemical combination, are identical with atoms. Most other gases, such as nitrogen, oxygen, hydrogen, have diatomic molecules ; ozone is triatomic. The molecule of a compound, on the other hand, must always contain at least two different atoms, and there is no limit to the number which it can contain. Thus a molecule of water contains three atoms, two of hydrogen and one of oxygen ; a molecule of alcohol contains nine : two of carbon, six of hydrogen, one of oxygen ; a molecule of starch may contain many thousands of atoms of only three elements.

The elementary atoms have been shown to possess limited and well-defined powers of combination. Only one atom of hydrogen can be made to combine with one atom of chlorine, and vice versa, to form hydrogen chloride ; similarly, one atom of oxygen combines with two of hydrogen to form water; one atom of nitrogen combines with three of hydrogen to form ammonia, and so on.

Valency

This combining power is known as valency. No element has been found with a lower combining power than hydrogen, so the valency of hydrogen is taken as unity. Oxygen is thus divalent, nitrogen trivalent, carbon tetravalent.

Valency therefore represents the number of atoms of hydrogen or element equivalent to

TABLE OF ATOMIC WEIGHTS

Hydrogen	(H)	1·008	**Strontium**	(Sr)	87·63
Helium	(He)	4·002	**Yttrium**	(Y)	88·92
Lithium	(Li)	6·940	**Zirconium**	(Zr)	91·22
Beryllium	(Be)	9·02	**Niobium**	(Nb)	92·91
Boron	(B)	10·82	**Molybdenum**	(Mo)	96·00
Carbon	(C)	12·00	**Ruthenium**	(Ru)	101·70
Nitrogen	(N)	14·01	**Rhodium**	(Rh)	102·91
Oxygen	(O)	16·00	**Palladium**	(Pd)	106·70
Fluorine	(F)	19·00	**Silver**	(Ag)	107·88
Neon	(Ne)	20·18	**Cadmium**	(Cd)	112·41
Sodium	(Na)	22·99	**Indium**	(In)	114·76
Magnesium	(Mg)	24·32	**Tin**	(Sn)	118·70
Aluminium	(Al)	26·97	**Antimony**	(Sb)	121·76
Silicon	(Si)	28·06	**Tellurium**	(Te)	127·61
Phosphorus	(P)	31·02	**Iodine**	(I)	126·92
Sulphur	(S)	32·06	**Xenon**	(Xe)	131·30
Chlorine	(Cl)	35·46	**Caesium**	(Cs)	132·91
Argon	(A)	39·94	**Barium**	(Ba)	137·36
Potassium	(K)	39·10	**Lanthanum**	(La)	138·92
Calcium	(Ca)	40·08	**Cerium**	(Ce)	140·13
Scandium	(Sc)	45·10	**Thulium**	(Tm)	169·40
Titanium	(Ti)	47·90	**Hafnium**	(Hf)	178·60
Vanadium	(V)	50·95	**Tantalum**	(Ta)	180·88
Chromium	(Cr)	52·01	**Tungsten**	(W)	184·00
Manganese	(Mn)	54·93	**Rhenium**	(Re)	186·31
Iron	(Fe)	55·84	**Osmium**	(Os)	190·20
Cobalt	(Co)	58·94	**Iridium**	(Ir)	193·10
Nickel	(Ni)	58·69	**Platinum**	(Pt)	195·23
Copper	(Cu)	63·57	**Gold**	(Au)	197·20
Zinc	(Zn)	65·38	**Mercury**	(Hg)	200·61
Gallium	(Ga)	69·72	**Thallium**	(Tl)	204·39
Germanium	(Ge)	72·60	**Lead**	(Pb)	207·22
Arsenic	(As)	74·91	**Bismuth**	(Bi)	209·00
Selenium	(Se)	78·96	**Niton**	(Nt)	222·00
Bromine	(Br)	79·92	**Radium**	(Ra)	226·05
Krypton	(Kr)	83·70	**Thorium**	(Th)	232·12
Rubidium	(Rb)	85·44	**Uranium**	(U)	238·07

Certain rare earths, and other elements of minor importance, are omitted.

hydrogen which can combine with one atom of the particular element.

It has been shown that the combining weight of an element represents the weight which is chemically equivalent to 1·008 grams of hydrogen, i.e. to one atom of hydrogen. Hence the valency of an element is given by the ratio atomic weight : combining weight. Since, however, for some elements the combining weight may have a number of values, the valency of these elements is also variable. This point is dealt with later; but, in general, the true valency of an element is the maximum value it exhibits in any of its compounds.

LESSON 5

Chemical Formulae and Equations

In order to represent the mechanism of chemical reactions as simply as possible, chemists have adopted an international system of symbols for the elements. These are given in the Periodic Table in page 91. In general, the element is represented by the initial letter of its Latin name or, where ambiguity would occur, by the first combined with the second or another letter. For example:

K	for potassium	(Latin—kalium)
Pb	for lead	(Latin—plumbum)
Au	for gold	(Latin—aurum)

Chemical Formulae

These symbols not only serve for the names of the elements but they have also a definite quantitative significance. Thus the symbol H represents an atom or atomic proportion —1·008 parts by weight—of hydrogen, Cl an atom or 35·46 parts by weight of chlorine, Na an atom or 23·0 parts by weight of sodium. The formula for a compound is then conveniently represented by writing the symbols of the elements together; for example, HCl is the formula for hydrogen chloride, NaCl for sodium chloride. These formulae indicate also the atomic relations of the elements present in the compound.

Chemical Equations

The use of a formula which conveys a precise knowledge of the composition of a compound has enabled chemists to express chemical reactions in terms of an algebraic equation. For example, the reaction between copper and sulphur may be written:

$$Cu + S \rightarrow CuS$$

which means that 63·6 grams of copper when added to 32·0 grams of sulphur produce (63·6 + 32·0) = 95·6 grams of copper sulphide. Similarly the formation of sodium chloride can be written:

$$Na + Cl \rightarrow NaCl$$
and of water, $H_2 + O \rightarrow H_2O$

Strictly speaking, in these two cases the proportions throughout the equations should be doubled, since the gases, oxygen and chlorine, exist in the free state as molecules, which are diatomic. The equations then become

$$2Na + Cl_2 \rightarrow 2NaCl$$
and $2H_2 + O_2 \rightarrow 2H_2O$

which have the same quantitative significance as before.

This method of expressing reactions by equations can be extended to every case. For example, the reaction between dilute sulphuric acid and zinc metal, which, as is shown later, yields hydrogen gas and zinc sulphate, may be written:

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

and means 65·4 grams of zinc + 98·0 grams of sulphuric acid produce 161·4 grams of zinc sulphate + 2·016 grams of hydrogen.

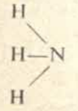
Graphic Formulae

These simple formulae give precise information about the composition of chemical compounds, but they do not convey anything of the nature of the bonds which hold the elements in combination. To express this aspect of a chemical compound chemists have adopted graphic or constitutional formulae. Thus:

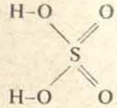
hydrogen chloride is written H–Cl

water H–O–H

ammonia



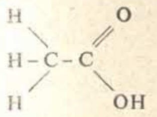
sulphuric acid



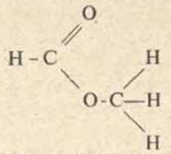
Each of these links or bonds between the atoms, shown as a line in the formulae, represents a "valency bond." Thus hydrogen is univalent; oxygen, divalent; nitrogen, trivalent; sulphur, hexavalent.

One important aspect of graphic formulae is that they offer an explanation of the marked difference in properties of some compounds which have the same chemical composition. Acetic acid—the chief constituent of vinegar—and methyl formate—a sweet, fruity-smelling liquid—both have the same formula $C_2H_4O_2$.

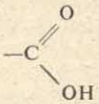
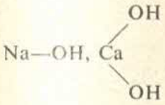
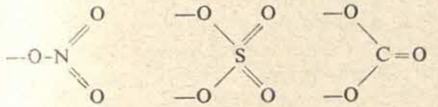
The graphic formulae of these substances are :



Acetic Acid



Methyl Formate

and it has been shown that all substances which contain the group or *radical*  possess acidic properties very like those of acetic acid. Similarly the basic properties common to the hydroxides of the metals, as, for instance, sodium and calcium hydroxides (caustic soda and slaked lime) :  etc., are due to the presence of the radical —OH, and the chemical properties common to nitrates, sulphates, carbonates, and so on to the radicals 

A radical, therefore, is a group of atoms which has its own characteristic properties and can take part in reactions as a chemical unit.

Of the 92 naturally occurring elements, 12 alone constitute more than 99 per cent. of the atmosphere, the earth's crust, and the ocean. Oxygen and silicon are by far the most widely distributed, forming together about three-quarters of the materials of the earth's surface. Of the metals, aluminium is the most common, occurring in granite (feldspar) and in clay. Iron constitutes only about four per cent. of the earth's surface, though it is probable that the proportion of iron in the centre of the earth is much higher. Carbon, which is the chief element in substances associated with living things, forms less than 0·2 per cent. of the matter of the earth's crust. In general the elements may be classified into the two main groups —" metals " and " non-metals." Between them is a small group of metalloids.

The metals, which are far the more numerous, possess well-known physical characteristics. With the exception of sodium and potassium, which are lighter than water, and mercury, which is a liquid, they are dense solids. They exhibit metallic lustre from a freshly-cut surface and take a high polish ; they are good conductors of heat and electricity, and can usually be beaten into thin plates (malleable) and drawn into fine wire (ductile). Non-metals in general show none of these properties. Many are gaseous—sulphur, phosphorus, and carbon are brittle solids—and, save for some forms of carbon, they are poor conductors of heat and electricity.

The chemical properties of metals and non-metals are also distinctive ; their basic

Period	Group I		Group II		Group III		Group IV		Group V		Group VI		Group VII		Group VIII	O
	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
1	H 1															He 2
2	Li 3		Be 4		B 5			C 6		N 7		O 8		F 9		Ne 10
3	Na 11		Mg 12		Al 13			Si 14		P 15		S 16		Cl 17		A 18
4	K 19		Ca 20		Sc 21		Ti 22		V 23		Cr 24		Mn 25		Fe 26 Co 27 Ni 28	
		Cu 29		Zn 30		Ga 31		Ge 32		As 33		Se 34		Br 35		Kr 36
5	Rb 37		Sr 38		Y 39		Zr 40		Nb 41		Mo 42		Ma 43		Ru 44 Rh 45 Pd 46	
		Ag 47		Cd 48		In 49		Su 50		Sb 51		Te 52		I 53		Xe 54
6	Cs 55		Ba 56		La 57 Ce-Lu 58-71		Hf 72		Ta 73		W 74		Re 75		Os 76 Ir 77 Pt 78	
		Au 79		Hg 80		Tl 81		Pb 82		Bi 83		Po 84		At 85		Rn 86
7	Fr 87		Ra 88		Ac 89		Th 90		Pa 91		U 92					

Fig. 2. The Periodic Table. The number under the symbol for the element is that element's atomic number.

differences are clearly shown in the reactions of the products formed when their oxides are added to water. Thus oxides of the non-metals yield acids on solution in water and are therefore called *acidic oxides* ; oxides of the metals yield bases and are called *basic oxides*. The oxides of some metals, e.g. arsenic—exhibit both mild basic and acidic properties and it is found that these elements are intermediate in character between metals and non-metals. They are also called *metalloids*.

When the elements are arranged in order of increasing atomic weight, an interesting regularity of physical and chemical properties becomes evident. This was first pointed out by the Russian chemist Dmitrij Mendeleeff (1839-1907), who showed in his periodic classification of the elements that "the properties of the elements are a periodic function of their atomic weights." Fig. 2 shows an arrangement of the elements in this way. The serial numbers shown are the "atomic numbers" of the elements. Starting with hydrogen, the elements are arranged horizontally in ascending atomic weight. It is found that chemically related elements recur at regular intervals, making *periods* at intervals of 2, 8, 8, 18, 18, and 32. This causes them to fall vertically into families or *groups* of allied chemical behaviour, e.g. VIIB, the halogens.

LESSON 6

Chemical Change and Equilibrium

ASSOCIATED with all forms of matter there are definite amounts of intrinsic or "internal" energy, and in a chemical reaction, which involves a fundamental change in the substances taking part, some of this chemical energy may be released or "degraded" in the form of heat.

Every chemical reaction involves a change in the energy of the system. In general, this energy change manifests itself as an evolution of heat to, or an absorption of heat from, the surroundings. Reactions in which the former takes place are said to be *exothermic* ; those in which the latter takes place are called *endothermic*. Exothermic reactions are by far the more common ; for example, most oxidation processes and such reactions as the neutralisation of an acid by a base are exothermic. The formation of ozone from oxygen is endothermic, as also are many of those reactions in which a chemical compound is decomposed into its elements.

It must be remembered that substances which in certain circumstances react vigorously and evolve a large amount of heat may not necessarily react at all under ordinary conditions. An unlighted candle is perfectly stable to air or oxygen, but if the temperature of the tallow is raised by lighting the wick the candle will continue to burn brightly. In other words, the process of oxidation goes on continuously if the tallow is first raised to a sufficiently high temperature. A piece of iron, on the other hand, if exposed to moist air will be slowly oxidised at room temperatures. In general, for every chemical reaction a certain temperature must be reached before the reaction can begin ; in many cases this coincides with ordinary room temperatures.

The unit of heat is the calorie, which is the amount of heat required to raise 1 gram of water through 1° C. of temperature. This unit is rather small for ordinary purposes, so that in practice the kilogram calorie, the heat required to raise 1 kilogram of water 1° C., is used. The kilogram calorie is equal to 1,000 calories ; it is written "kg. cal." or simply "cal."

Heat of Formation

Since all substances have definite amounts of internal energy, it is to be expected that in the formation of a compound from its elements a definite amount of heat will be evolved or absorbed. This represents the difference in the energy content of the compound and the elements from which it is composed, and is called the "heat of formation of the compound." It is expressed in calories (or kg. cals.) per gram molecule of the compound ; thus in the case of the burning of sulphur in air, the heat of formation of the compound, sulphur dioxide, is the heat evolved when 32·07 grams of sulphur combine with 32·0 grams of oxygen to give 64·07 grams of sulphur dioxide, and is 70·2 kg. cals. This may be written :

$$\text{S (solid)} + \text{O}_2\text{ (gas)} \rightarrow \text{SO}_2\text{ (gas)} + 70{\cdot}2\text{ kg. cals.}$$

Since SO_2 is an exothermic compound, the heat of formation has a positive sign ; in the case of an endothermic compound it has a negative sign. Similarly, the heat of formation of hydrogen chloride is 22 kg. cals., that is :

$$\tfrac{1}{2}\text{H}_2\text{ (gas)} + \tfrac{1}{2}\text{Cl}_2\text{ (gas)} \rightarrow \text{HCl (gas)} + 22\text{ kg. cals.}$$

and the heat of formation of sulphuric acid from sulphur trioxide and water, or, as it is usually known, *the heat of solution of* SO_3, is 21·32 kg. cals. The equation is written thus :

$$\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 + 21{\cdot}32\text{ kg. cals.}$$

From an investigation of the heat changes occurring in a large number of reactions, a

German-born Russian, Germain Hess, was able to show that the heat evolved (or absorbed) in any chemical transformation is dependent only on the initial and final stages of the system and is independent of the intermediate stages by which the change is brought about. This is known as Hess's Law of Constant Heat Summation. It is exemplified in the following reactions :

$$\begin{array}{l} C + \tfrac{1}{2}O_2 \rightarrow CO + 26 \text{ kg. cals.} \\ CO + \tfrac{1}{2}O_2 \rightarrow CO_2 + 68 \text{ kg. cals.} \\ \hline C + O_2 \rightarrow CO_2 + 94 \text{ kg. cals.} \end{array}$$

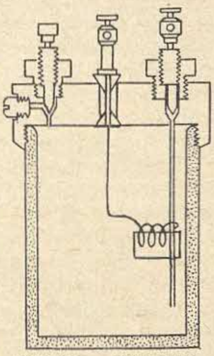
that is, the heat evolved in the direct oxidation of carbon to carbon dioxide—viz. 94 kg. cals.—is the same as that evolved if the carbon is first oxidised to carbon monoxide and the monoxide then converted to the dioxide.

Heat of Combustion

The heat of combustion of an element or a compound is the heat evolved when one gram molecule of the element or compound is completely oxidized. In the case of ethylene :

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O + 342 \text{ kg. cals.}$$

the heat of combustion is 342 kg. cals. With the aid of Hess's Law and a knowledge of the heats of formation of CO_2 and H_2O, which are in most cases the final products, they can be used to calculate heats of formation and also probable heats of reaction of many organic compounds.



BOMB CALORIMETER. Fig. 3. For measuring heat of combustion.

Measurements of the heat of combustion can be carried out in an apparatus called the *bomb calorimeter*. The usual arrangement, shown in Fig. 3, consists of a steel bomb, containing a platinum dish in which the substance can be heated electrically. The bomb is filled with a large excess of oxygen, tightly sealed, and the heat of combustion is estimated by immersing the calorimeter in a known weight of water and measuring the rise in temperature.

Velocity of Chemical Reactions

It follows from the Kinetic Theory that the velocity of a chemical reaction depends on the number of collisions between the molecules in unit time. The velocity of the reaction is therefore influenced by the temperature, pressure, concentration of the reacting substances, catalysis, and light.

If two gaseous substances, A and B, are brought into contact under conditions in which they can react, then according to the kinetic theory of gases the molecules of A and B are in a constant state of rapid motion, and reaction takes place when molecules of A and B collide or at any rate come within each other's sphere of influence. If at the start there is certain concentration of A and B, there will be a certain definite number of collisions per second between the molecules of A and B, and therefore a definite rate of reaction. If, now, the concentration of A, that is, the number of molecules of A, is doubled, the number of collisions per second, and therefore the rate of reaction, will also be doubled. If the concentration of B is also doubled, the number of collisions per second, and therefore the rate of reaction, will be increased to four times its initial value. In other words, *the speed of a chemical reaction is proportional to the concentrations of the reacting substances.* This law was discovered by the Norwegian chemists Guldberg and Waage, and is called the Law of Mass Action.

The speed of chemical reaction is also greatly affected by the temperature. It was shown that in the case of a gas an increase in temperature increases the kinetic energy of the molecules, and therefore the velocity with which they are moving to and fro. If the speed of the moving molecules is increased, the probability of collisions between them is also increased, so that in the case of the two gaseous substances A and B *an increase in temperature results in an increase in the rate of reaction.* Different reactions are affected by temperature in a different degree, but, as a very rough approximation, it may be taken that an increase in temperature of 10° C. almost doubles the speed of reaction.

Reversible Reactions and Equilibrium

It has been mentioned that by varying the concentrations of the substances taking part and also the products, the reaction between sodium chloride and sulphuric acid can be reversed. Such a reaction, which can be made to proceed in either direction, is called a *reversible reaction* ; it is usually written with arrows pointing in both directions thus :

$$NaCl + H_2SO_4 \rightleftharpoons NaHSO_4 + HCl$$

The reaction which occurs when steam is passed over red-hot iron is another example of a reversible reaction. It may be written

$$3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$$

which implies that if hydrogen is passed over heated iron oxide (Fe_3O_4), steam and metallic iron are produced. In the case of the " forward reaction ", there is a large excess of steam and the hydrogen is carried away before it can react with the iron oxide ; in the " back reaction " (right to left), the concentration of hydrogen is considerably the greater, so that the reverse reaction takes place.

The question now arises, what would happen in a closed system in which neither hydrogen nor steam was allowed to escape? Assume that the reaction starts between the iron and steam. At first the forward reaction is very vigorous, iron oxide and hydrogen being produced; but as the concentration of hydrogen increases, the back reaction begins to take place. After a certain time, provided the temperature remains constant, the reaction appears to have ceased altogether; i.e. *the system has assumed a state of chemical equilibrium.*

The velocity of a chemical reaction is proportional to the concentrations of the substances taking part. At the outset, therefore, when the concentration of steam is at a maximum and the concentration of hydrogen is zero, the velocity of the forward reaction is at a maximum and the velocity of the back reaction is zero. As the concentration of steam diminishes and the concentration of hydrogen increases, the forward reaction becomes slower and slower, while the velocity of the back reaction gradually increases. Ultimately a point is reached where the velocities of the two reactions, forward and backward, are equal.

This is the point at which chemical equilibrium occurs; in each second the amount of steam decomposed is equal to the amount of hydrogen which reacts to form steam; in other words, provided the temperature is constant, the ratio of the concentrations of steam and hydrogen at the equilibrium point is constant. If these concentrations—usually measured in gram molecules—are represented by (H_2O) and (H_2), and K is the *Equilibrium Constant of the Reaction*, then:

$$\frac{(H_2O)}{(H_2)} = K$$

In the general case, where $A + B \rightleftharpoons C + D$

the equilibrium constant, $K = \frac{(C)\,(D)}{(A)\,(B)}$

Since the velocities of reactions are affected differently by changes in temperature, it is to be expected that the position of equilibrium of a balanced or reversible reaction will also change with temperature. Thus, in the case just given, at 200° C. equilibrium occurs when the ratio of steam to hydrogen is approximately 20 : 1, at 400° C. it is 6 : 1, and at 1,500° C. it is almost 1 : 1. This really means that if a mixture of equal volumes of steam and hydrogen is passed over iron filings or iron oxide heated to 1,500° C., no change will occur.

Since the position of equilibrium depends on the concentrations of the substances present, any factors which tend to reduce these concentrations will automatically change the position of equilibrium. In the case of the reaction between sodium chloride and sulphuric acid, the hydrogen chloride, being volatile, immediately passes out of the system, so that the reaction can proceed practically to completion in the forward direction. Similarly, when, say, a solution of sodium carbonate is added to a solution of calcium chloride, calcium carbonate is immediately precipitated:

$$Na_2CO_3 + CaCl_2 \rightarrow 2NaCl + CaCO_3$$

Since calcium carbonate is practically insoluble in water, it is to all intents and purposes entirely removed from the field of the reaction which then proceeds to completion as is indicated in the above equation.

These two factors, the volatility and solubility of the products, are of immense importance in determining the position of equilibrium. Theoretically, at least, every chemical reaction is reversible; it is factors such as the volatility and solubility of the various substances taking part which determine how far the reaction can proceed in either direction.

LESSON 7

Catalysis and Catalytic Reactions

THE state of equilibrium in a chemical reaction is determined by the temperature and the concentrations of the substances taking part. In a reaction which involves gaseous substances, if the volume of the system is kept constant the concentrations of the gases present can be expressed in terms of their pressures. For a general case, therefore, it can be said that the state of equilibrium is dependent on the three factors, temperature, pressure, and concentration of the substances present.

It is of considerable importance to be able to predict what change in the condition of equilibrium would be brought about by a change in one or more of the variable factors. To do this, use is made of a principle discovered by a Frenchman, Henri Le Châtelier (1850–1936), which has a very wide application to chemical and physical processes.

If one of the factors determining the equilibrium of a system is altered, the equilibrium adjusts itself in such a way as to annul, as far as possible, the effect of the change. Thus, when ice is compressed—as, for example, under the blade of a skate—it melts, thereby decreasing its volume. In other words, for any system in equilibrium an increase in pressure will change the equilibrium in the direction in which a decrease in volume takes place. Similarly, when water is heated to 100° C. it evaporates as steam ; the conversion of each gram of water from the liquid to the gaseous state at 100° C. involves the absorption of 536 calories of heat ; an increase in temperature, therefore, changes the equilibrium in the direction in which heat is absorbed.

Examples of the law are numerous ; in the combination of hydrogen and oxygen to form steam, viz. :

$$2H_2 + O_2 \rightarrow 2H_2O$$

2 volumes of hydrogen combine with 1 of oxygen to form 2 volumes of steam ; a decrease in volume therefore occurs and the reaction is favoured by increased pressure.

Catalytic Reactions

The velocity of many chemical reactions may be considerably influenced in another way, which is of great importance in industrial chemistry. The decomposition of potassium chlorate into potassium chloride and oxygen takes place much more rapidly if a small amount of manganese dioxide is also present, and when the reaction has ceased the manganese dioxide appears to be entirely unchanged. It was the Swedish chemist Jons Berzelius (1779–1848) who grouped together a large number of processes of this kind, in which the velocity of the reaction was markedly affected by the presence of certain substances in minute, sometimes infinitely minute, amounts. Berzelius called such processes *catalytic reactions* (Greek *kata*, down ; *lusis*, loosing), and the substances which acted in this way he called catalytic agents or catalysts.

One of the commonest examples of a catalyst is moisture. For example, moist hydrogen and oxygen gases combine to form water with explosive violence at about 1,100° C., but if they are first thoroughly dried they may be subjected to a temperature of 1,800° C. without any reaction taking place. Similarly metallic sodium, which burns vigorously if warmed and plunged into moist chlorine gas, can be heated above its melting point without reaction if the gas is previously thoroughly dried.

Surface Reactions

Numerous examples also exist of solids which have a profound effect on the rate of chemical reaction. Hydrogen and oxygen do not combine at all at ordinary temperatures, but if a mixture of the gases is passed over metallic platinum or, better still, platinum in the finely divided form known as platinum black or platinum sponge, combustion takes place so rapidly that the platinum may become red-hot.

Reactions of this kind, which take place on the surface of a solid, are called *surface reactions*, and they are due to the fact that the gases are condensed in layers or "absorbed" on the surface, and thus brought into more intimate contact with one another. This explains why finely divided platinum is a more powerful catalyst than the solid metal, since the surface area of a given weight of metal is much greater in the former case.

Catalysts in Nature

Nature makes prolific use of catalysts ; in the animal body, the transformation of the food consumed into the bone, flesh, and blood, and in the vegetable organism, the synthesis or building up of the complex solid structure and also of the perfumes, essences, and colours are all brought about under the influence of catalytic agents. Chief amongst these organic catalysts are the enzymes (Greek *enzumos*, leavened), which are themselves produced within the living cells. Of these perhaps the best known are the diastase of sprouting barleycorn and the zymase of yeast, used in the fermentation of sugars and in preparing alcoholic beverages.

Owing to the necessity for producing an article of manufacture as rapidly as possible, catalysts have become increasingly important in industrial chemistry. Of the processes involving catalysts three may be mentioned, namely, the manufacture of sulphuric acid, the hardening of oils, and the cracking of petroleum. The description of the first of these is in the Lesson on sulphur compounds.

Hardened Oils

Most solid fats are compounds of glycerin with "saturated" acids, such as palmitic and stearic acids, the chief constituents of beef-fat. Liquid oils, such as linseed oil, whale and other fish oils, olive oil, and so on, are glycerin compounds of "unsaturated" acids, which differ from saturated acids only in that they contain less hydrogen. Oleic acid, for example, the chief constituent of olive oil, contains two hydrogen atoms less per molecule than stearic acid.

Solid fats are widely used in the manufacture of soap and foodstuffs, such as margarine, lard, etc. ; liquid oils are generally strong-smelling and quite unsuitable for either of these purposes. It is of considerable importance to convert liquid oils into a solid form and this is done by the industrial process of *hydrogenation*, using nickel as a catalyst. If hydrogen is passed through the liquid oil in the presence of finely divided nickel, the hydrogen is absorbed and the unsaturated oil converted into a solid fat.

Crude petroleum oil consists of a mixture of a large number of compounds of carbon and hydrogen called hydrocarbons, of varying complexity ; those with only a small number of carbon atoms in the molecule are gases or volatile liquids which burn with a hot non-luminous flame, while the higher members of the group are heavy viscous oils or solid waxes.

The process of refinement of petroleum—called *fractional distillation*—consists in heating the crude oil gradually and condensing the vapours which boil off between certain definite ranges of temperature. The first portion contains the more volatile constituents and is used as petrol ; the next fraction, kerosene, is used mainly as an illuminant ; the third fraction, called " gas oil," is too thick to be used in paraffin lamps, and too thin to be used as a lubricant. It was therefore of very little practical use until the discovery was made that if this oil was heated to about 400° C. under a pressure of 6 atmospheres or more, part of the molecules split off as lighter hydrocarbons, which could be used for internal combustion engines or as an illuminant. This process—called *cracking*—was found to proceed very much more easily under the catalytic action of a hot metallic surface, and the method now in use is to pass the gas oil vapours at pressures of 90-500 lb. to the square inch through red-hot tubes which are heated to about 450° C. A very large proportion of the total petrol used in the world to-day is obtained by cracking gas oils.

LESSON 8

Osmotic Pressure

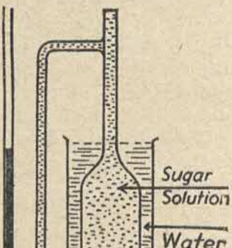
In a solution the dissolved molecules pass freely through a filter paper. It is possible, however, to obtain a membrane which will prevent the passage of dissolved molecules while allowing solvent molecules to pass freely. Such a membrane, which is selectively permeable to some substances and not to others, is known as a *semi-permeable membrane*. These are of frequent occurrence in nature. Supported by the walls of vegetable cells are delicate membranes which allow the passage of water into the cell, but prevent the diffusion outwards of the dissolved salts which are necessary for the growth of the cell. Similarly the walls of a blood corpuscle are permeable to water but not to dissolved salts.

If a solution of cane sugar contained in a porous pot, treated as described below, is immersed in a vessel of water, the water molecules can diffuse either into or out of the pot, whereas the sugar molecules are retained by the pot.

There are equal numbers of molecules bombarding the inside and outside of the porous pot, but since all the molecules on the outside are water, whereas only a fraction of the molecules inside the pot are water, there must be a diffusion of water into the pot. This diffusion is known as *osmosis*. As a result the water rises in the manometer tube setting up a pressure ; eventually this pressure becomes sufficiently great to prevent any further diffusion. The pressure which is just sufficient to prevent water from diffusing through the membrane is the *osmotic pressure*.

Measurement of Osmotic Pressure

The first attempts to compare the osmotic pressures of solutions were based on this selective property of semi-permeable membranes. Thus a blood cell, if put into a solution of lower salt concentration, and therefore lower osmotic pressure than the blood itself, grew larger and larger until it finally burst. Quantitative measurements were carried out in this way by Pfeffer (1897), who prepared a chemical membrane by filling an unglazed porcelain pot with potassium ferrocyanide and immersing it in a solution of copper sulphate. When the diffusing liquids met in the walls of the pot, a fine membrane-like precipitate of copper ferrocyanide was formed. The pot was then carefully washed and was used by Pfeffer to determine the osmotic pressures of sugar solutions, as shown in Fig. 4; the pressure was recorded by means of a manometer.



OSMOTIC PRESSURE. Fig. 4. Pfeffer's method determining osmotic pressure by means of a chemical semi-permeable membrane.

A Dutch chemist, Van't Hoff (1852-1911), showed from measurements of this kind that the variations of osmotic pressure with changes in temperature and pressure are essentially the same as those of the pressure exerted by a gas. For example, the osmotic pressure was found to be directly proportional to the concentration of dissolved substance and also to the absolute temperature. In the first case, since the concentration is inversely proportional to the volume of the solution,

P (osmotic pressure) $= \frac{k}{v}$ (*cf.* Boyle's Law),

$P_t = P_0 (1 + \alpha t)$ (*cf.* Charles's Law), where P_t and P_0 denote the osmotic pressures at temperatures t° C. and

0° C. respectively, and α is the usual coefficient of expansion.

As in gases, the combined effect of temperature and concentration may be summed up in the equation $PV = nRT$, where R has the same significance as in the gas law. The osmotic pressure exerted by a dissolved substance is therefore identical in value with the gaseous pressure which that substance would exert if it were in a state of vapour under the same conditions of temperature, pressure, and volume.

For example, a given weight of alcohol, when dissolved in water to form a solution of volume V, exerts an osmotic pressure P. Suppose that the molecules of solvent are now removed and that the molecules of alcohol fill the same volume V, the temperature remaining constant. What will be the result under these conditions ? The gaseous pressure of the alcohol vapour would be the same as the osmotic pressure which it exerted in the dissolved state, viz. P.

Molecular Weight from Osmotic Pressure

Van't Hoff also showed that Avogadro's law of gaseous volumes was equally applicable to dilute solutions. Thus equal volumes of all solutions which exert equal osmotic pressures at the same temperatures contain an equal number of dissolved molecules. In the case of gases Avogadro's law leads at once to the conclusion that the molecular weight of a gas at N.T.P. (0° C. and a pressure of 1 atmosphere) occupies 22·4 litres. Similarly, if the molecular weight of a substance is dissolved in 22·4 litres of solution at a temperature of 0° C., it will exert an osmotic pressure of 1 atmosphere. Hence, if the osmotic pressure exerted by a known weight of substance dissolved in a known volume of solution at 0° C. is known, the weight of substance which, if dissolved in 22·4 litres, would exert a pressure of 1 atmosphere can be calculated. This is the molecular weight of the substance.

Unfortunately, it is difficult to obtain accurate measurements of osmotic pressure. There are, however, three other properties of solutions which are directly connected with the osmotic pressure and which are capable of accurate determination.

Methods of Indirect Measurement

They are lowering of vapour pressure, elevation of boiling point, and lowering of freezing point, all of which are proportional—like the osmotic pressure—to the number of dissolved molecules. Measurements of vapour pressure are also somewhat difficult, so that in practice the other two methods are used to determine the molecular weight of dissolved substances.

Since the depression of freezing point is dependent on the number of dissolved molecules and the volume of the solution, if W is the weight of dissolved substance of molecular weight M, S the weight of solvent, Δ the depression of freezing point, and K a constant depending on the solvent, then :

$$\Delta = K \times \frac{W}{MS}$$

If W/M and S are both unity, then $\Delta = K$.

Hence K is the depression of freezing point caused when 1 gram molecule of substance is dissolved in 1 gram of solvent, and it is called the molecular lowering of freezing point. In practice it is more convenient to use 100 grams of solvent ; the value of K is then 18·50 for water, 49·0 for benzene. In the above equation, if S is constant and equal to 100, then :

$$\text{molecular weight} = \frac{K \times W}{\Delta}$$

so that if K, W, and Δ are known, the molecular weight can be found.

In the investigation of molecular weights by this method, it was found that while most carbon compounds, such as ethyl alcohol, cane sugar, etc., when dissolved in water gave values in agreement with those obtained by other methods, inorganic acids, bases, and salts all gave abnormally high values of the depression of freezing point. Thus salts like sodium chloride and potassium chloride gave values which were twice as large as those anticipated from the number of dissolved molecules, while salts like calcium nitrate and calcium chloride gave values which were rather less than three times as large. In general, the solutions and substances which gave normal values were found to be non-conductors of electricity, while those which gave abnormal values were found to be conductors.

Ionic Theory

The explanation of these anomalies was later found in the ionic theory of Svante Arrhenius (1859–1927), a Swede ; it was shown that while non-conductors of electricity, like cane sugar, alcohol, and so on, exist in the molecular state in solution, inorganic acid bases and salts, when dissolved in water, are dissociated to a greater or less extent into charged particles of ions. The total number of particles present—undissociated molecules and ions—is in such cases considerably greater than the number of dissolved molecules.

Thus, for sodium chloride, which dissociates almost completely into sodium and chlorine ions, the number is approximately twice as large, and since Δ the depression is proportional to the number of particles present, it is also twice as large.

For salts like calcium nitrate, which are partially dissociated in solution, giving rise to one calcium and two nitrate ions, Δ was found to be between two and three times as large as that calculated for the undissociated molecules alone.

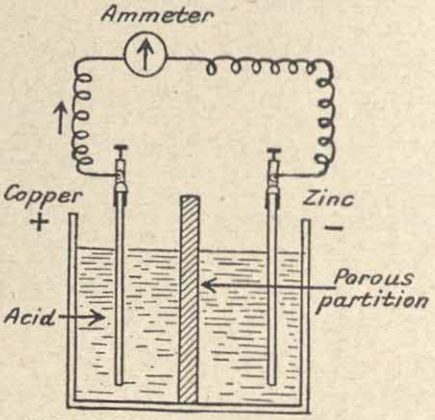
LESSON 9

Electro-Chemistry

A CHEMICAL reaction involves a transformation not only of the form but also of some of the energy inherent in the substances taking part. As was shown in Lesson 6, on the heat of chemical reactions, this inherent or chemical energy is, in general, transformed into heat energy ; under certain conditions, however, the energy which is transformed or released in a chemical reaction may take another form, viz. electrical energy.

This was first observed at the end of the 18th century, by the Italian chemist Alessandro Volta (1745–1827), who found that whenever two metals were combined with certain liquids to make a circuit, an electric current was produced. Using strips of copper and zinc and a solution of sulphuric acid—an arrangement now known as the voltaic cell, in honour of its discoverer (Fig. 5)—Volta was able to obtain a continuous current of electricity. The zinc gradually dissolves in the sulphuric acid ; a chemical reaction is, therefore, continually taking place, and chemical energy continuously transformed into electrical energy. In such a cell the two metal plates are called *poles* or *electrodes*, the one from which the electricity flows outside the cell—viz. the copper—being the positive pole or anode, the other—the zinc—the negative pole or cathode. Just as the flow of water in a pipe depends on the pressure or head of water and the dimensions of the pipe, so the flow of an electric current depends on the electrical pressure—the electromotive force or E.M.F. of the cell—and the resistance of the wire to the flow of current. Various other types of voltaic cell have been constructed, one of the best known being the Daniell cell, in which copper and zinc electrodes are immersed in a solution of copper sulphate. The chemical reaction which takes place is represented by the equation :

zinc + copper sulphate → zinc sulphate + copper.



VOLTAIC CELL. Fig. 5. Copper and zinc electrodes are dipped into sulphuric acid.

Electrolysis

If the ends of two wires which are connected to an electric circuit are placed in a vessel containing pure distilled water or a solution of sugar in water, it is found that no current flows in the circuit ; these liquids do not conduct an electric current. If, however, the sugar solution is replaced by a dilute solution of sulphuric acid, the flow of electricity is no longer interrupted. Substances which dissolve in water may therefore be divided into two groups—those, like sulphuric acid, which conduct an electric current, and those, like sugar, which do not. The former are called *electrolytes* and include all acids, many bases and inorganic salts ; the second group are called non-electrolytes and include many organic substances, such as glycerin, alcohol, etc. When an electric current is passed through the solution of an electrolyte, some chemical decomposition of the conducting solution takes place. For example, with a dilute solution of sulphuric acid, bubbles of hydrogen gas appear at the cathode, and oxygen is liberated at the anode ; if a solution of copper sulphate is taken, a deposit of metallic copper forms on the cathode and oxygen is again set free at the anode. This process of decomposition by means of an electric current is called *electrolysis*. The mechanism of the process was explained by the chemist Michael Faraday (1791–1867), who in 1834 carried out a series of exact investigations of the quantitative aspects of electrolytic dissociation.

Faraday's Laws of Electrolysis

The phenomenon of electrolytic decomposition led Faraday to conclude that, whenever an electric current is passed through a conducting solution, the substance in solution breaks down into charged particles which migrate towards one or other of the electrodes and thus act as carriers of the current. These electrically charged moving particles he called *ions* (Greek, meaning " wanderers "). Those which were positively charged and were therefore attracted to the oppositely charged cathode were called *cations*; those which were negatively charged and moved towards the anode, *anions*. The decomposition of sulphuric acid was then explained according to the equation :

$$H_2SO_4 \rightleftharpoons H^+ + HSO_4^- \rightleftharpoons 2H^+ + SO_4^{=}$$

The hydrogen ions are discharged on the surface of the cathode and set free as elementary hydrogen ; the sulphate ions have their charge neutralised by the anode and react with water :

$$2SO_4 + 2H_2O \longrightarrow 2H_2SO_4 + \overset{\nearrow}{O_2}$$

The net result of the electrolysis of sulphuric acid, therefore, is that hydrogen is liberated at the cathode, oxygen is given off at the anode (as shown by the oblique arrow), and sulphuric acid gradually accumulates round the anode.

With copper sulphate a similar process takes place. The positively charged copper ions migrate to the cathode, where they are discharged and deposited as fine particles of metallic copper ; the negatively charged sulphate ions are discharged at the anode and react with water to give free oxygen and sulphuric acid as before. It may be said that in the electrolysis of a dissolved salt the metal ion migrates to the cathode, the acid ion to the anode ; whether the metal will be deposited on the cathode depends on its tendency to react with water after it has passed from the ionic to the atomic state. For example, in the electrolysis of a sodium salt, metallic sodium is not deposited on the cathode ; it immediately reacts with water thus :

$$2Na + 2H_2O \longrightarrow 2NaOH + \overset{\nearrow}{H_2}$$

and hydrogen gas is set free at the cathode. These are the principles underlying the electrolytic refinement of metals, electroplating, and so on ; examples of their application occur in the Lessons on the preparation of the metals.

Faraday showed that in the process of electrolysis the amount of substance liberated at either one of the electrodes is strictly proportional to the total quantity of electricity which has been passed through the cell. It is independent of the temperature and concentration of the solution, and also of the area of the electrodes exposed in the solution. Moreover, if the same current is allowed to pass through a series of solutions, as shown in Fig. 6, the amount of substances liberated at the electrodes in each cell is proportional to the chemical equivalent of the element. For example, the quantity of electricity which liberates 1·008 grams of hydrogen from dilute sulphuric acid also liberates 23 grams of sodium from sodium chloride solution, 107·88 grams of silver from silver nitrate solution, 63·6/2=31·8 grams of copper from copper sulphate solution, and so on.

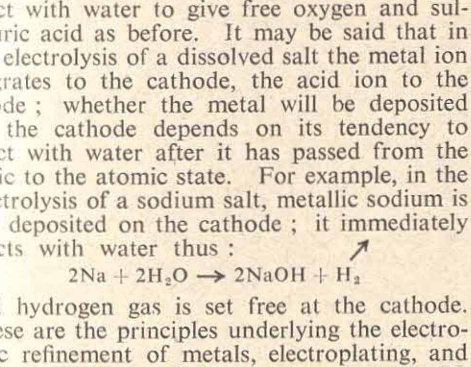


Fig. 6. Chemically equivalent quantities of substances set free by passing the same amount of electricity through the solutions.

Faraday found that the quantity of electricity required to liberate one gram equivalent, that is, the equivalent weight expressed in grams, of an element is equal to 96,540 coulombs; a coulomb, the unit quantity of electricity, corresponds to the passage of 1 ampere of current for 1 second. Faraday's figure has since been corrected to 96,490 coulombs ; this amount of electricity is generally known as the *faraday* and is usually denoted by the symbols + or —. Since the equivalent weight of a univalent element is the same as the atomic weight, one equivalent of each ion in such a case, e.g. Na^+, carries with it one faraday of electricity ; similarly, a divalent ion carries two, e.g. Cu^{++}, a trivalent ion, three, e.g. Fe^{+++}, and so on. Faraday's laws, therefore, afford an excellent method of determining the chemical equivalent of an element—sometimes called the electro-chemical equivalent in this case. The quantity of electricity actually used in such determinations is estimated by weighing accurately the amount of silver or copper deposited in a specially designed cell called a voltameter.

Migration of Ions

The tendency of solutions of electrolytes to conduct an electric current is due to the motion of the ions. If the ions move very rapidly the electrolyte concerned would be expected to have a high conductivity ; if the ions move slowly we should expect the electrolyte to be a poor conductor. In other words, the electrical conductivity of solutions is dependent on the speed with which the ions move.

The actual velocities of migration of various ions have been measured in an apparatus similar to that shown in Fig. 7. A moderately dilute solution of some coloured salt, such as copper sulphate, is introduced, together with some gelatin, into the lower portions of the U-tube. When the jelly has set, a dilute solution of a colourless salt, e.g. potassium sulphate, is added to each limb and, the positions of the coloured boundary having been marked, the terminals are connected to a battery. The jelly prevents diffusion currents but permits the migration of the ions, as is shown in the case of copper

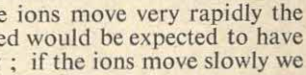


Fig. 7. Migration of coloured ions towards oppositely charged electrode. Coloured substance made into jelly with gelatin in the bottom of the U-tube.

sulphate by the movement of the blue boundary towards the cathode, and in the case of salts such as potassium chromate, potassium permanganate, etc., by the movement of the coloured boundary towards the anode.

By comparing the distances which the boundaries of the coloured jelly moved in a given time, it was possible to determine the relative speeds of migration of the ions. By this method it was found that the hydrogen (H^+) and hydroxyl (OH^-) ions move considerably faster than any others, the H^+ ion being about five times as fast as most others, e.g. Na^+ and Cl^-.

The Ionic Theory

In putting forward his laws of electrolysis Faraday assumed that it is the electric current which causes the molecules to dissociate into ions. If this were so, a certain minimum amount of electricity would be necessary before electrolysis could begin. In no case was this found to be so, the merest trace of current being sufficient to start the decomposition. In 1887 the Swedish physicist Svante Arrhenius put forward the theory that the molecules of an electrolyte when dissolved in water break up or *ionise of their own accord*, and that the positively and negatively charged ions exist quite independently of each other in the solution.

On this assumption Arrhenius was able to account for the abnormal values of osmotic pressure, depression of freezing point, etc., which all electrolytes appeared to show (*see* Lesson 8). Since these properties are dependent on the total number of particles present in the solution (whether undissociated molecules or ions), the splitting up of the molecules into ions would obviously cause an increased effect upon the osmotic pressure, etc. Investigations of the degree of this ionic dissociation—that is, the proportions of dissolved molecules which ionise in solution—have shown that the abnormalities of osmotic pressure can be roughly accounted for on this basis, and the ionic theory of Arrhenius is accepted as the correct explanation. The mechanism of this dissociation is indicated in the following equations :

$$\begin{aligned}
&NaCl && \rightleftharpoons Na^+ + Cl^- \\
&AlCl_3 && \rightleftharpoons Al^{+++} + 3Cl^- \\
&Na_2CO_3 && \rightleftharpoons 2Na^+ + CO_3^{=} \\
&H_2SO_4 && \rightleftharpoons H^+ + HSO_3^- \rightleftharpoons 2H^+ + SO_4^{=} \\
&NaOH && \rightleftharpoons Na^+ + OH^-
\end{aligned}$$

All acids in solution give the H^+ ion, all bases the OH^- ion ; the common properties of all acids and of all bases are due to the presence in their solutions of these ions. It must be remembered that the ions of elements have specific properties which are quite different from those of their atoms. Thus copper metal has a reddish colour, while the cupric ion is blue ; chlorine gas is yellowish-green and very poisonous, while the chlorine ion is colourless, and solutions containing it, e.g. NaCl, are in general non-poisonous.

When an electrolyte dissolves in water dissociation at once occurs and in the case of most salts and of the so-called strong acids and bases it is believed to be practically complete. A solution of sodium chloride in water contains, therefore, no molecules of sodium chloride but only sodium and chlorine ions and its properties will be simply the properties of these ions. Other electrolytes, which are known as weak electrolytes and are usually organic acids and bases, are only partially dissociated. For example, with acetic acids there is a definite equilibrium,

$$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$$

In such a case the proportion of dissolved molecules which dissociates into ions is called the *degree of dissociation*, and this may be approximately determined by measuring the conducting power of the solution. The equilibrium is governed by the Law of Mass Action and consequently the degree of dissociation increases as the solution is diluted, becoming one for an infinitely dilute solution.

If the degree of dissociation is large, the solution will contain a large number of ions, and since its ability to conduct an electric current depends on the production of charged ions, solutions which are good conductors are also highly ionised. This is particularly so in the case of acids and bases owing to the high velocity with which the H^+ and OH^- ions migrate. These facts offer a convenient method of comparing the relative strengths of acids and bases by measuring their electrical conductivities.

Since strong electrolytes are practically completely dissociated, their reactions are the reactions of their ions. Consider the neutralisation of HCl, a strong acid, by NaOH, a strong base. HCl in solution is almost entirely present as H^+ and Cl^- ; NaOH as Na^+ and OH^-. On mixing, nothing happens to the Na^+ and Cl^- since the salt NaCl is a strong electrolyte. Water however is only very feebly dissociated into the ions H^+ and OH^- and therefore these ions combine to form water, and this is the essential reaction in all neutralisation. This may be represented as :

$$\begin{aligned}
NaOH &\rightarrow Na^+ + OH^- \\
HCl &\rightarrow H^+ + Cl^- \\
H^+ + OH^- &\rightarrow H_2O \\
\text{Hence } Na^+ + OH^- + H^+ + Cl^- &\rightarrow Na^+ + Cl^- + H_2O
\end{aligned}$$

Similarly, the hydrolysis of a weak salt—that is, a salt of a weak base or a weak acid, e.g. aluminium chloride—may be written :

$$\begin{aligned}
AlCl_3 + 3H_2O &\rightleftharpoons Al(OH)_3 + 3HCl \\
HCl &\rightleftharpoons H^+ + Cl^-
\end{aligned}$$

and since $Al(OH)_3$ is only slightly ionised in solution, and is slowly precipitated as a white gelatinous solid, a solution of $AlCl_3$ contains H^+ ions and shows an acid reaction to litmus.

LESSON 10

Colloidal Solutions

Water is one of the most familiar compounds in nature; in the form of rivers, lakes, and seas it covers about three-quarters of the surface of the earth. The composition of water by volume was first determined by Henry Cavendish (1731–1810), who showed that it was produced when two volumes of hydrogen were made to combine with one volume of oxygen under the influence of an electric spark. This was later proved to be correct by experiments on the electrolysis of water, which always gave hydrogen and oxygen in the volumetric proportions of 2 to 1. The molecule of water, therefore, contains two atoms of hydrogen and one of oxygen ; its formula is H_2O.

The composition of water by weight is a matter of great importance, since it gives the ratio of the combining weights of hydrogen and oxygen, which is the basis of the quantitative aspect of chemistry. The first value was obtained by the Frenchman Jean Dumas (1800–84) ; he passed pure, dry hydrogen over heated copper oxide, which was reduced to copper according to the equation :

$$CuO + H_2 \rightarrow Cu + H_2O$$

Dumas obtained the ratio of 1 : 8 for the combining weights of hydrogen and oxygen. This value was corrected by Edward Morley (1838–1923), an American who carried out some extraordinarily accurate syntheses, using weighed quantities of the pure gases, which were exploded by means of an electric spark. Morley's value of 2·016 : 16·00 has been confirmed.

Solutions

The solubility of substances depends on the nature of the liquid in which they are being dissolved—the solvent. For example, sugar dissolves readily in water, but sand and chalk do not. Similarly, many important organic compounds, e.g. nitrocellulose lacquers, are insoluble in water, but are soluble in organic liquids, e.g. benzene.

In general, when a solid dissolves in a liquid its molecules separate from one another and become interspersed evenly among the molecules of the solvent. A solution therefore appears perfectly homogeneous even under the highest powered microscope, and the dissolved molecules can pass freely through the fine pores of a filter-paper. Since the forces of cohesion existing between the molecules in the solid have been overcome, the process of solution entails a change of energy. This may manifest itself in the absorption or, in some cases, the evolution of heat. In the former case an increase in temperature naturally supplies the deficiency and hence increases the solubility of the substance. That is why sugar and salt are more soluble in hot water than in cold.

In studying the diffusion of liquids the Scottish chemist Thomas Graham (1805–69) found that substances which in solution could pass freely through a porous membrane or parchment were in general well-defined crystalline solids, and so called them crystalloids. There was another large group of substances which also formed apparently homogeneous solutions, but which were unable to diffuse through a parchment membrane. These substances, e.g. starch, albumen, etc., were in general non-crystalline, and Graham called them colloids. This property of selective diffusion through a semi-permeable membrane is called *dialysis*.

Crystalloids and Colloids

Recent investigations of these liquids have shown that the difference is not one of kind but merely of degree, and that the terms crystalloid and colloid cannot be taken to indicate different kinds of matter but merely different states of matter. Thus many substances once considered distinctively colloid, e.g. albumen and gelatin, have now been obtained in the crystalline form and vice versa. It is, therefore, more appropriate to refer to the second class of liquids as colloidal solutions, or as in the colloidal state.

It has been shown that when particles of a substance are very much larger than those of the solvent in which they are dissolved or suspended, the substance is in colloidal solution. If they are much the same size, the solution behaves as a *true solution*. In the colloidal state the particle size is between 10^{-5} and 10^{-7} cms.

A convenient method of preparing colloidal solutions of metals such as platinum, gold, silver, and so on, is to strike a direct current arc between two electrodes made of the particular metal beneath the surface of well-cooled water. Other methods depend on the nature of the colloidal substance.

Properties of Colloids

Colloidal substances have been found to exist in two forms, the soluble or hydrosol form—more briefly, *sol*, and the gelatinous, partially precipitated or hydrogel form—*gel*. The difference is chiefly one of degree, and the sol form can be readily converted into the gel form—or coagulated—by various physical means. Thus when a soluble colloid is heated, it is coagulated, as, for example, in the setting of an egg when boiled. Similarly, coagulation or precipitation may be effected by the addition of a salt or, in fact, of any electrolyte.

Colloids have two other important properties : they carry an electric charge and exhibit Brownian movement. The former of these can be shown by what is called a migration experiment. If a colloidal solution of arsenic sulphide is placed in a U-shaped tube and the terminals from a battery inserted into the separate ends, when the current is passed through the solution the arsenic sulphide migrates towards and is precipitated on the positive electrode. The particles of arsenic sulphide therefore carry a negative charge of electricity, a property which is common to most colloids. Some, such as ferric hydroxide, carry a positive charge, and, in the above experiment migrate towards the negative electrode.

LESSON 11

The Physical Chemistry of the Atom

THE quantitative laws of chemical combination are based on the assumption, put forward by John Dalton, that all matter is composed of minute, indestructible particles called *atoms*. For a long time it was believed that these atoms could not be further subdivided—the word atom means indivisible—and that the 80 or so different atoms which constituted the then known elements were completely unique and had nothing in common with one another. The first suggestion that this was not so came from the English chemist, William Prout (1785–1850) ; he put forward the theory, shortly after Dalton's hypothesis, that hydrogen atoms were the fundamental ones, and that the atoms of the heavier elements were aggregates of numbers of hydrogen atoms. It was found, however, that the atomic weights of many elements were not integral multiples of the weight of the hydrogen atom, so the Prout hypothesis was abandoned. However, it has again come into its own, though the situation is rather more complicated than Prout anticipated.

But although the indivisible atom proved sufficient for the purposes of the chemist, it did not satisfy the physicist ; and as a result of a remarkable series of discoveries towards the close of the 19th century it was definitely proved that the atoms themselves are composed of even more minute particles, called electrons and protons. They are discussed from the purely physical point of view in our Course on PHYSICS.

Cathode Rays

The first suspicion that there might be an atom of electricity arose from Faraday's experiments on electrolysis of salt solutions (*see* PHYSICS). It was found that if a given amount of electricity is passed through solutions of the salts of univalent metals, the amounts of metals deposited are proportional to the atomic weights—that is, the weight of the atoms—of these metals. Moreover, the amount of electricity required to deposit the atomic weight of a divalent metal is twice that required for the atomic weight of a univalent metal, that for a trivalent metal three times, and so on. This suggested that in electrolysis the atoms are accompanied by a unit of electricity or some integral multiple of this unit. The actual proof of its independent existence did not appear until the examination of the passage of electricity through gases.

At ordinary pressures all gases are relatively poor conductors of electricity ; for example, it requires about 30,000 volts to break the insulation of an inch of air. If, however, air contained in a vacuum tube is exhausted to a pressure of about 1/1000th of an atmosphere (about 1 mm.), it not only becomes a good conductor but also begins to glow with a brilliant pink luminosity. If the pressure in the tube be further decreased to a few hundred thousandths of an atmosphere (about 0·01 mm.), cathode rays, or streams of negatively charged particles, are produced. They are explained in some detail in the Course on PHYSICS.

Sir J. J. Thomson (1856–1940) showed, in fact, that they are free atoms of negative electricity, and, moreover, are a universal constituent common to all atoms. They are called *electrons* (*see* further under PHYSICS where also X-rays, an effect of the electron stream, are discussed).

The Proton and Ionisation

The discovery of the atom of negative electricity led to the search for the atom of pure positive electricity. Since atoms are, in general, electrically neutral, the removal of one or more negatively charged electrons might be expected to leave a positively charged residue. This was actually shown to be the case by the German scientist, Eugene Goldstein (1850–1930), who in 1886 demonstrated the existence in a vacuum tube of streams of positively charged particles which were shot along the tube in the opposite direction to the cathode rays.

Measurements of the deflection of these rays caused by the influence of magnetic and electric fields carried out by Sir J. J. Thomson, Aston, and others, have shown that the velocity of positive particles is, in general, much less than that of electrons—it is of the order of a few hundred kms. per second ; moreover, the ratio of charge to mass is about the same as in electrolysis, that is about 1/2000th as much as in the case of the electron. It must be assumed, therefore, that these positively charged particles are some thousands of times heavier than the electrons, and, in fact, are merely atoms of matter having a positive charge.

Particles produced in this way are called *ions* ; the process of ionisation, therefore, consists merely in knocking out one or more electrons from the atom and leaving behind the relatively heavy positive ion containing the rest of the atom. Ionisation may be caused by high electrical potentials, by swift particles, such as the electrons themselves, or by energy-rich rays, such as X-rays or ultra-violet light.

Since the hydrogen atom is the lightest known, it is generally believed that the hydrogen ion is the smallest positively-charged particle. It is called the *proton*, and has been shown to be one of the fundamental bricks in the structure of all atoms (the other being the electron). The discovery of the electron and the proton led at once to the modern theories of the structure of the atom, based chiefly on the phenomenon of radioactivity. In 1932 experiments carried out at the Cavendish Laboratory at Cambridge confirmed the existence of a positively charged particle having the same mass as the electron, and known as the *positron*. The positron is always accompanied by an electron and is only a product of bombardment, not a part of the atomic structure. That year Sir James Chadwick (b. 1891) discovered the *neutron*, a particle with mass but no charge. The union of two protons with two neutrons yields an α-particle. This is dealt with later.

Radium and Radioactivity

The study of the discharge of electricity through gases resulted in the discovery of three kinds of radiation. These are cathode rays, which are due to electrons ; positive rays, due to positively charged ions ; and X-rays, which are set up when cathode rays are reflected from some hard surface. All three have the properties of affecting a photographic plate, exciting fluorescence, and ionising gases through which they pass.

In 1896 Henri Becquerel (1852–1908) noticed that crystals of uranium compounds continually emitted rays which had similar effects to those obtained by means of a vacuum tube. He found, for example, that a photographic plate, even though well wrapped in black, light-proof paper, was extremely sensitive to the presence of a small amount of a uranium salt.

The intensity of these rays is completely unaltered by any of the factors (heat, light, concentration, electric fields, etc.) which have such a marked effect on chemical reactions. The phenomenon is, in fact, due to an intrinsic property of the atoms, and its discovery led to the development of a new branch of science called *radioactivity*.

Pioneer Work of the Curies

In 1898 Madame Curie (1867–1934), and Schmidt, showed that compounds of the element thorium possessed radioactive properties of about the same intensity as those of uranium. In the same year Pierre Curie (1859–1906) and his wife noticed that some natural ores from which uranium is extracted—called pitchblende—were as much as 8 times as radioactive as the uranium and thorium which they were known to contain. This suggested the presence of other, more strongly radioactive substances ; and by fractional crystallisation, in which both the filtrate and the precipitate were tested by means of an electroscope for radioactive materials, Madame Curie was able to separate the salts of two extremely active elements. The first of these, always associated with bismuth, was called polonium. The other, of atomic weight 226·5, exactly analogous in chemical properties, spectrum, etc., to barium, was called radium ; it is at least a million times more radioactive than uranium.

Rays Emitted by Radium

The first analyses, carried out by Sir Ernest (later Lord) Rutherford (1871–1937), showed that the rays were of three types, which were analogous to those of the Crookes tube, and which, like them, could be readily distinguished by the differences in their power of penetrating matter, and also by the effect caused by subjecting them to an electric or a magnetic field. They were classified by Rutherford into *alpha-* (α), *beta-* (β), and *gamma* (γ) rays. Their properties may be summarised as follows :

α-rays are composed of positively charged particles (as shown by the deflection in a magnetic field) having a velocity about one-sixteenth that of light (12,000 miles per second) and a mass of the same order of magnitude as the masses of the atoms ; their penetrating power is small, and they are stopped by a few centimetres of air.

β-rays have been proved to be identical with cathode rays ; they are composed of negatively charged electrons having a velocity approximately nine-tenths that of light. Because of their minute size and

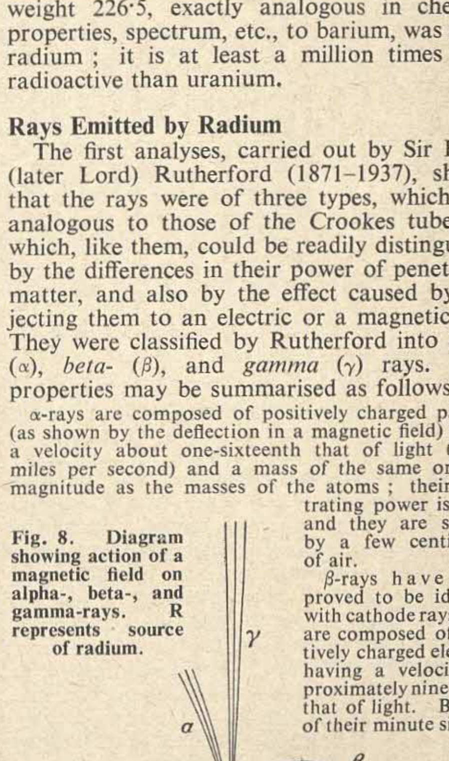


Fig. 8. Diagram showing action of a magnetic field on alpha-, beta-, and gamma-rays. R represents source of radium.

[illegible]

The penetration of each of these rays vary considerably according to the radioactive source. For example, the penetrating power of γ-rays from radium is generally at least twice as great as that of γ-rays emitted by uranium. Moreover, the proportions of α, β, and γ-rays in the total radiation vary according to the radioactive substance, and in some cases, for example, polonium, which emits only α-rays, all these radiations are not emitted by one and the same element.

Energy of Radium

It was noticed that the temperature of radium-bearing materials is always slightly higher than that of the surrounding air, and in 1903 Pierre Curie measured, by means of a special calorimeter, the amount of energy continually being released in the form of heat. [illegible]

Transmutation of Elements

It was observed by the Curies that substances placed in a vessel together with a radium salt [illegible] radioactive [illegible], which gradually disappeared when the substances were removed from the vicinity of the radium. These and other observations pointed to the formation of a gaseous emanation, which was produced by the radium [illegible]. This was [illegible] by Rutherford [illegible] radioactive gas. [illegible]

[illegible]

very curious fact was observed by Rutherford that after a certain length of time (30 days, in fact) the amount of radon in contact with a given amount of radium reached a maximum value, which was never exceeded, however long the radium was left. The only explanation seemed to be that the radon itself was undergoing spontaneous radioactive decay, and by isolating some of the gas Rutherford was able to show that this was the case. Radon emits at first only α-, then later β- and γ-rays very strongly; [illegible] in fact, it is far more intensely radioactive even than radium: after four days only one-half of the gas remains, after eight days only one-quarter, and after one month less than one-thousandth.

Since the rate of decay of radon, like that of radium itself, is entirely unaffected by changes of temperature, pressure, and so on, the energy causing this radioactivity cannot come from any external source, and must therefore, come from the atoms themselves.

The rather startling conclusion is then arrived at, that in emitting its rays, the element radium is gradually decaying, and at the same time is producing a new element, radon, which is itself spontaneously disintegrating. As will be seen later, the change from radium to radon is, in fact, only one of a long series of successive changes of similar character, which actually begin with the element uranium.

Disintegration of the Atom

Radium, then, in emitting its rays, gives rise to a new element, radon, which, like its parent substance, also gives off radiations and disintegrates. As a result of phenomena of this kind, characteristic of all radioactive substances, the conclusion is reached that the process of radioactivity is the outward and visible sign that the element is being slowly transformed into another. Since such a transformation must involve a change of one kind of atom into another, the process is an atomic one. Moreover, the transformations do not take place gradually but in sudden jerks.

There is, for example, no intermediate step between the disintegration of radium and the formation of radon. The transformations occur suddenly and explosively, each atomic explosion being accompanied by the shooting out of the various rays.

Counting Alpha-Particles

As has been mentioned, it follows from the nature of the deflection which α-rays experience in a magnetic field that they are positively charged particles. Moreover, the same method of calculation as that employed for cathode rays showed that the ratio of charge to mass was always about half the value of that ratio for the hydrogen ion. It has to be assumed, therefore,

[illegible]

Range of Atomic Projectiles

[illegible]

Disintegration of Radium

[illegible]

Radium and Lead

[illegible]

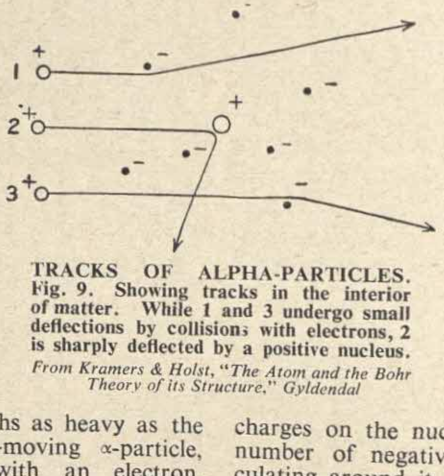
LESSON 12

The Structure of the Atom

As a result of the discoveries of the electron and the phenomena of radioactivity, the old view of the atom as a solid, indivisible unit was ultimately discarded. It was proved that all atoms are composed of positive and negative particles, and the following questions naturally arose: what positions do these particles take up with respect to one another? how many of each kind are present? and how are these internal arrangements of the atom connected with its physical and chemical properties?

Rutherford's Nuclear Theory

Much light was thrown on these questions by Rutherford's experiments on the penetration of matter by swift α-particles. These particles are shot out from radium with a speed of about 10,000 miles per second, and so, in spite of their lightness, they have a comparatively large energy; they are, in fact, able to pass through plates of mica and aluminium up to five-hundredths of a millimetre in thickness, and, since it is extremely unlikely that they pass in between the densely packed atoms of the plate, it must be concluded that they travel clean through the atoms themselves.



TRACKS OF ALPHA-PARTICLES. Fig. 9. Showing tracks in the interior of matter. While 1 and 3 undergo small deflections by collisions with electrons, 2 is sharply deflected by a positive nucleus.
From Kramers & Holst, "The Atom and the Bohr Theory of its Structure," Gyldendal

Now, α-particles are doubly charged helium atoms having a mass about four times that of the hydrogen atom, while electrons are approximately only one eighteen-hundredths as heavy as the hydrogen atom. A swift-moving α-particle, therefore, on colliding with an electron, would merely brush it aside; large deflections must be caused by something much more massive. Rutherford's work led to the hypothesis that practically all of the mass of the atom is concentrated into a positively charged and very small nucleus, and that the large deflections were due to the tremendous forces of repulsion suddenly created when an occasional positively charged α-particle passed very near to the nucleus—shown diagrammatically in Fig. 9.

ALPHA-RAYS OF RADIUM. Fig. 10. Two alpha-ray cloud tracks.

These phenomena were demonstrated rather more conclusively by the experiments of Charles T. R. Wilson (b. 1869), an English physicist, who obtained photographs of the cloud tracks left by particles on passing through moist gases. An enlarged picture of two such cloud tracks is shown in Fig. 10. The straight line is the path traced out by an unobstructed particle, the kink in the other being due to a collision between an α-particle and the nucleus of the atom.

Continued researches of this kind definitely proved the correctness of Rutherford's nuclear theory of the atom. It is now known that an atom consists of a dense, positively charged nucleus, in which practically the whole of its mass is concentrated, and a number of negatively charged electrons, which circulate about the nucleus in orbits of different diameters, in much the same way as the planets circulate about the sun. The outer boundaries of the atom are marked by the orbits of the outermost electrons, contact between two atoms being the result of the forces of repulsion between the outer electrons. Rutherford was able to show that the diameter of the nucleus is in the order of 10^{-13} of a centimetre, the diameter of the atom itself being of the order of 10^{-8} of a centimetre, i.e. about 100,000 times as large as the nucleus.

Since atoms are, in general, electrically neutral, the numbers of positive charges on the nucleus must be equal to the number of negatively charged electrons circulating around it.

Nuclear Charge and Atomic Number

Considerable importance therefore attaches to the determination of the magnitude of the positive charge of the nucleus, as this is equivalent to determining how many electrons the atomic shell contains. As a result of the work of Rutherford and a Dutch physicist, Van der Broek, it was proved that the charge on the nucleus and therefore the number of planetary electrons is equal to the order number of the element in the periodic table, its *atomic number*.

This was later verified by the English chemist Henry Moseley (1887–1915), who investigated the X-ray spectra of different elements.

As previously explained, X-rays are vibrations similar in nature to light waves, but of much shorter wavelength, and are obtained whenever cathode or β-rays impinge on some solid substance. Moseley found that the frequency of vibration of X-rays was directly connected with the atomic number of the element from which they were reflected, and by measuring the frequency it was possible to determine the atomic number without any knowledge of the atomic weight of the element concerned. Most of the characteristic properties of the atom, especially the chemical properties, depend on the number of its planetary electrons and so on the nuclear charge ; the atomic number is more significant than the atomic weight, and clears up many anomalies in the first periodic classification of the elements based on atomic weights. The atomic numbers are given in the Table of Elements on page 91.

Isotopes

One convincing proof of the importance of the atomic number was furnished by the discoveries of Frederick Soddy (b. 1877), Fajans, Russell, and others, of the existence of isotopes. These elements have slightly different atomic weights (nuclear masses), but are practically identical in physical and chemical properties, and so were placed in the same group of the periodic table (Gr. *isos* = equal, *topos* = place). The first examples were found among the radioactive substances. Lead is often found associated with uranium and thorium. Determinations of the atomic weight of lead from these two sources have given values of 206 and 208 respectively. These values agree very well with the disintegration theory that the loss of 8 α-particles by a uranium atom gives an element of atomic weight $238 - (8 \times 4) = 206$, and of 6 α-particles by a thorium atom, $232 - (6 \times 4) = 208$. Ordinary lead obtained from other sources has an atomic weight of 207·2, and may therefore be considered to be a mixture of the two isotopes.

Many non-radioactive elements which have fractional atomic weights were shown to be mixtures of isotopes by the English physicist Francis W. Aston (1877–1945), using a mass spectrograph. For example, chlorine normally has an atomic weight of 35·46, and is a mixture of isotopes of atomic weights 35 and 37 in the ratio of about 4 to 1. This even suggests that the hydrogen atom may be a fundamental unit in the structure of all atoms.

It has been shown that the chemical individuality of the atom is defined by the number of the planetary electrons and, consequently, by the charge of the nucleus. If, therefore, the nuclear charge is constant, although the mass of the nucleus is altered an isotope is produced. This has been proved.

The emission of α-particles from radioactive elements indicated that the nuclei of these atoms are not elementary, indivisible particles, but contain a certain number, at any rate, of helium nuclei—that is, helium atoms stripped of their two electrons. It was later suggested by the Danish chemist Niels Bohr (b. 1885), that the β-particles (electrons) shot out by radium also came from the nucleus of the atom, and that, in addition to the planetary electrons, there are—in radioactive atoms, at any rate—some special nuclear electrons. The question arose : is the helium nucleus the fundamental brick in the nuclear structure of all atoms ?

Some evidence that this might be so was provided by the phenomena of radioactive distintegration, which showed that the helium nucleus, if not an elementary unit, was a singularly stable aggregate. The fact that the weights of the lighter atoms are not simple multiples of 4, however, indicated that the helium atom is not an elementary particle ; and since the hydrogen nucleus, or proton, is the smallest positively charged unit known, the simplest assumption is that the nuclei of the atoms are aggregates of protons " cemented " together, as it were, by a certain number of electrons. This was proved to be true by Rutherford, who, by bombarding light atoms such as nitrogen and aluminium, with streams of α-particles succeeded in dislodging some protons from the atomic nuclei.

The Atomic Nucleus

The phenomena of isotopes is explained as being due to the simultaneous loss by an atomic nucleus of one, two, or more neutrons, or else the same number of both protons and electrons. Thus the nuclear charge remains constant, and so the chemical properties of the atom ; but the mass is decreased by one, two, or more units of weight. According to the theory, then, the atom of hydrogen consists of a positively charged nucleus of mass 1·0078 with one negatively charged electron revolving around it ; the next largest atom, helium, has an atomic number 2 and a mass of 4. The helium nucleus, therefore, contains 2 protons and 2 neutrons, and has 2 electrons revolving around it. The nitrogen atom has atomic number 7 and atomic weight 14 ; there are thus 7 protons and 7 neutrons in the nucleus, and 7 extra-nuclear, planetary electrons. In every case the chemical properties of the element are determined by the charge on the nucleus or the atomic number ; that is, by the number of protons in the nucleus, and as long as this is unaltered the element is unchanged. If one or more planetary electrons are removed or added, as during ionisation, the properties of the atom are altered, but it is essentially the same atom. But a change in the nucleus charge produces a different element.

Formerly the nucleus was supposed to contain a number of cementing electrons, the excess of protons over electrons equalling the atomic number ; but the discovery of the neutron simplified the picture of the nucleus. When the number of protons and neutrons exceeds 104, however, the nucleus is insufficiently stable to prevent the charges from flying apart, and spontaneous disintegration results.

It has been shown that the nucleus of the helium atom is composed of 2 protons and has a mass of 4·00. Two protons and two neutrons of mass 1·0081 and 1·0067 give a mass of 4·0296 ; so that, even neglecting the very small mass of the electrons, the formation of a helium atom results in the disappearance of 0·03 units of mass, or rather less than 1 per cent. of the mass of the 4 hydrogen nuclei.

This startling fact is in entire opposition to the old classical theory of the conservation of mass. The modern view, however, put forward by Albert Einstein (1879–1955) in his Relativity Theory (*see* the Course on PHYSICS), is that mass, being the result of positive and negative electric charges, is merely another form of energy, and that a decrease in mass corresponds to the emission of a definite amount of energy in some form. This theory has received considerable support from the discovery of cosmic radiation. This radiant energy, which is constantly falling on to the earth from outer space, is presumably liberated by the mutual destruction of positive and negative particles.

Using Einstein's formula (energy = mass × c^2, c being the velocity of light), it can be calculated that the amount of energy liberated by the " destruction " of one gram of matter would be equivalent to that obtained by burning 3,000 tons of coal. Or, to return to the helium atom, the amount of energy liberated in the formation of one ounce of helium from hydrogen would provide one million horse-power for seven years.

Until 1939 these fantastic stores of sub-atomic energy remained beyond the reach of man, though theory suggested that they explained how the sun and the stars were able to emit radiation in unending quantity. But in 1939 the fission of the uranium nucleus by neutron bombardment prepared the way for the greatest technological revolution.

The experiments which led to the discovery of uranium fission were devised by Otto Hahn (b. 1879) for a different purpose, namely, the building up of artificial " transuranic " elements, heavier than any found in nature. A neutron bombardment having been carried out, a search was made in the target material for signs of such atoms; but instead chemical analysis showed the presence, first of barium, and then of other elements midway in the table of elements.

Lise Meitner and Frisch interpreted this to mean that the neutron bombardment had resulted, not in the absorption of the neutrons within uranium nuclei, but in the actual disruption of the nuclei into two rather unequal parts. Jean Frédéric Joliot (b. 1900) in France and Fermi and Szilard in America showed that when this happened, apart from the two unequal fission fragments, a variable numble of neutrons were also released.

The Chain Reaction

Since the number of these neutrons released from the broken uranium nuclei could be greater than the number used in the initial bombardment, an entirely new and revolutionary phenomenon had been revealed, a self-perpetuating chain reaction involving the production of an ever-increasing amount of energy. In short, the fission of uranium nuclei produced more energy than was needed to start the process and needed no further energy introduced from outside once it had begun.

This chain reaction is not a necessary result of any bombardment of a mass of uranium. Special conditions must be arranged. A large number of released neutrons will be lost to the continuing process, some being absorbed into unfissioned nuclei (thereby creating the transuranic elements for which Hahn had been looking), others being absorbed by any chemical impurities existing within the uranium mass, and others being lost beyond the boundaries of the mass.

Bohr, Frisch, and Peierls realized that only the rarer isotope of uranium, U/235, was responsible for the fission phenomenon and that for practical purposes the chain reaction required the separation of this isotope from the far commoner U/238.

Moreover the chain reaction is more easily induced by slow-moving neutrons whose original velocity has been slowed down by collisions with molecules of lighter substances such as graphite and " heavy water."

Artificial Elements

When a neutron is captured by a nucleus of U/238, a series of electron emissions takes place very rapidly, forming, first, element 93 or neptunium, and then element 94 or plutonium. More recently elements 95 Americium, 96 Curium, 97 Berkalium, and 98 Californium have been produced in the atomic pile ; and in 1954 element 99, unnamed at the time of writing. These man-made elements, known as the transuranium series, do not exist in nature.

All these elements have similar properties to uranium 235, and when separated from the uranium and fissile products become further sources of material for atomic energy. Originally a large amount of uranium was needed to produce a relatively small quantity of plutonium and the production depended upon the world supply of uranium. This problem was solved by the use of "breeders" in which the output of plutonium exceeds the intake of uranium.

A further source of radioactive material can be created by bombarding thorium in an atomic pile. By neutron absorption the thorium is transformed into a new, non-natural isotope of uranium 233, capable of inducing a chain reaction. U/233 is chemically interesting as the initiator of a new series of radioactive changes, in the course of which it gives rise to a new form of radium with a comparatively short half-life. Thus a new series of radioactive substances has been formed starting from a radio element not existing in nature.

If U/235 absorbs a neutron, a violent reaction takes place with the release of enormous quantities of energy. The nucleus of the newly formed U/236 divides into two parts of approximately equal mass with the release of more neutrons which in turn bombard surrounding fissionable material. This chain reaction under certain conditions proceeds with great rapidity to cause an atomic explosion. British scientists exploded their first atomic weapon in 1952, under the direction of Sir William Penney (b. 1909), Director of the Atomic Weapons Research Establishment. Later the Americans announced the production of a thermo-nuclear weapon. The energy of the sun is believed to result from the synthesis of helium from hydrogen, and in the "hydrogen bomb" it is probable that plutonium is exploded producing tremendous temperatures. This temperature is sufficient to produce helium from tritium or deuterium (heavy water) with the release of immeasurable energy.

Britain's Atomic Energy Authority was centred at Harwell, Berkshire, under the direction of Sir John Cockcroft (b. 1897). At Harwell two atomic piles operated to produce radioactive material and to supply data for the more efficient piles. The first pile, called GLEEP (Graphite Low Energy Experimental Pile), used uranium as its source of energy. The chain reaction is controlled by absorbing the neutrons produced in blocks of graphite, during which process heat is evolved and can be converted into steam to drive turbines, etc. The second pile, BEPO (British Experimental Pile O), started up in 1948, was designed to develop 6,000 kW of nuclear energy. Factories were established for the processing of uranium both before and after use.

In 1955 British scientists announced the first comprehensive plan for the peaceful application of atomic energy and disclosed that the first two atomic power stations were under construction. The station at Calder Hall, Cumberland, was designed to use a gas-cooled uranium pile, with graphite as a moderator, to produce energy as heat and also to "breed" plutonium, the latter to be used in a more complex, liquid-cooled pile at Dounreay, Caithness. It was estimated that these stations would produce electricity at a cost equal to that produced by the more conventional means, at a saving of 6 million tons of coal a year. Eight more stations were planned to be built and in operation by 1965. Apart from the research into atomic power, there was a continuous programme of fundamental research being carried out throughout the country.

Considerable research goes on in all branches of science and industry, using the large numbers of radioactive isotopes which are produced by irradiation in the atomic pile. Naturally occurring elements can also be irradiated, and these "tagged" elements, which emit radioactive particles, can be traced wherever they go. For example, radioactive iodine if taken into the body is used by the thyroid gland and by measurement of the amount of irradiation from the gland an estimate of its function can be made. At the government radio-chemical establishment at Amersham, Bucks, these isotopes are finally processed and dispatched to hospitals and research centres all over the world.

LESSON 13

Atomic Types and Structures

When the elements are arranged in order of increasing atomic numbers and in periods which represent the periodicity of chemical properties, it is found that each period ends with an inert gas. The peculiar chemical and physical stability of the atoms of these elements leads to the belief that the outer shell of electrons in them has a very stable structure. Thus, for example, it requires an electrical force of 25 volts to remove one electron, that is, to ionise helium ; only 5 volts are necessary to ionise lithium. This view is supported by the fact that elements which immediately precede or follow the inert gases tend to attain their structures wherever possible. For example, sodium, which has one electron more than neon, readily loses it to form a stable sodium ion, Na^+ ; while chlorine, which lacks one electron to complete the argon structure, readily gains one to form the stable chloride ion, Cl^-. It appears, therefore, that the inert gases mark important transition points.

The development of the second quantum group from lithium to neon takes place quite regularly, and is repeated in the development of the third quantum group from sodium to argon ; hence the marked chemical resemblances between analogous elements in these two short periods. The first two long periods, which come next, each contain 18 elements ; in addition to the building up of an outer electronic group of 8, the outer but one group in each case expands from 8 to 18, and it is a matter of some importance to determine where this expansion takes place. In both groups it has been shown to begin with the third element ; thus potassium has the structure (2) (8) (8) (1), and calcium (2) (8) (8) (2), while scandium is (2) (8) (9) (2).

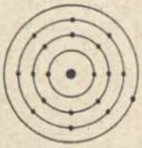


Fig. 11. Diagram of K, showing two electrons in inner orbit, eight in next two, one in outer orbit.

The building up of the third quantum group to 18 then continues more or less smoothly to copper (2) (8) (18) (1), after which the outer (fourth) group is progressively completed. These elements, shown in the periodic table, are called transition elements, and show remarkable chemical and physical properties. They all possess variable valency, catalytic properties, and form coloured ions—that is, solutions of their salts are coloured pink, yellow, green, blue, etc. Also they all possess paramagnetic properties.

Properties of Quantum Groups

Each one of these chemical properties can be readily explained as arising from the expansion of the inner quantum group. It is known that the energy difference between an orbit in the first sub-group of the fourth quantum group and the last sub-group of the third quantum group is relatively small. A transition from one of these orbits to the other is therefore not very difficult to bring about, which accounts for the phenomenon of variable valency. Moreover, the absorption of a quantum of visible light does not entail a very considerable energy change, so that the colours of the ions of these elements, which arise from the absorption of visible light, are also doubtless due to the same cause.

Paramagnetism arises from a slightly different cause ; it is due to the fact that in these variable structures the magnetic fields caused by the rotation of the electronic charges are not exactly balanced, as they are in the more stable structures, and the atoms tend to orient themselves in a certain way in the presence of a magnetic field.

After the second long period in the table comes a period containing 32 elements. Here two expansions of inner quantum groups take place, the fourth from 18 to 32, the fifth from 8 to 18. As in the previous two periods, therefore, we find a group of transition elements again, this time 22, 13 of which—called the rare earths—are so alike in chemical properties as to be almost indistinguishable. All these elements show to a very marked degree the characteristic properties of transition elements.

The last period is incomplete, the elements after lead (82) showing progressive instability of the nucleus.

Types of Atoms

To summarise : the Bohr theory leads to the recognition of four types of atoms :

(1) Those with complete electronic groups, such as the inert gases, which are very stable and do not form chemical compounds.

(2) Those in which all but the highest quantum group are complete, as, for example, the elements of the first two short periods ; these elements have a fixed number of valency electrons and form colourless ions.

(3) Those having the two outermost electronic groups incomplete : these are the transition elements, possessing coloured ions, and exhibiting variable valency and paramagnetism.

(4) Those in which three outer groups are imperfect, show properties and characteristics of class (3) to an even more marked extent, and are very similar chemically.

The next question is : to what extent can the formation of chemical compounds be interpreted in terms of the electronic theory ?

Valency and the Electron Theory

Valency has been defined as the power which the atoms possess of combining with one other. It was shown in Lesson 4 that when atoms come together under the right conditions they form a valency link, rather as though they have been attached to each other by hooks. A brief glance at some of the commoner compounds reveals at once the great variety of ways in which this power of forming links can take effect. For example, common salt—NaCl—a stable, crystalline compound which dissolves readily in water, gives sodium and chlorine ions ; sugar, though stable, crystalline and soluble in water, does not ionise ; methane, CH_4, is a very stable gas, which is insoluble in water ; ammonia, NH_3, which in many respects is like methane, reacts with hydrogen chloride to give a salt-like solid, ammonium chloride, which is ionised in water. In addition, there is another type of compound, discovered by the Swiss chemist, Alfred Werner (1866–1919), and called a co-ordination compound, in which two apparently stable molecules unite to form a third, for example, $PtCl_4(NH_3)_6$.

In general it may be said that chemical evidence points to three types of hooks or linkage between atoms : ionisable links, sometimes called polar links, as in NaCl ; non-ionisable or non-polar links, as in most organic compounds ; and co-ordination links of Werner, which unite apparently saturated molecules.

The first definite hypotheses to account for these various types of linkage in terms of the accepted electronic theory were put forward independently in 1916 by the German physicist Walther Kossel (b. 1888) and the American chemist Gilbert N. Lewis (1875–1946). Kossel investigated polar or ionisable linkage, and found that atoms which possessed most strongly the property of forming ions were, in general, one or two places removed from an inert gas. As has been mentioned, this is undoubtedly due to the tendency of these elements to attain to the inert gas structure, and when an electro-positive and an electro-negative element of this type come together, this can be mutually achieved by an actual transference of electrons from one to the other.

Thus, in the case of sodium and chlorine the sodium gives its spare electron to the chlorine to form one polar or electrovalent link.

Na, (2) (8) (1) and Cl, (2) (8) (7)

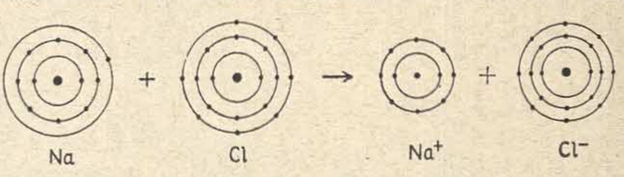
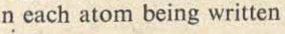


Fig. 12

If the element has two electrons too many, e.g. Ca, it forms a divalent link, that is, it hooks itself to another atom in two places, and so on. Kossel's theory explained very well the nature of the link between atoms which were essentially dissimilar in character. It could not, however, be applied to molecules formed by the union of two similar atoms, as, for example, in the diatomic elementary gases like oxygen, hydrogen, nitrogen, and compounds composed of two electro-negative elements such as sulphur dioxide, carbon monoxide, and so on. The explanation of these types of valency was due to Lewis.

Lewis's Theory of Compounds

Lewis also assumed that in forming compounds in this way the atoms strive to attain a stable electronic configuration ; but whereas in the Kossel linkage one electron is considered to be transferred from one atom to the other, in the Lewis linkage two electrons are shared equally by both atoms, one coming from each. The formation of a chlorine molecule from two atoms may then be represented thus ; only the outer shell of 7 electrons is given, the electrons in each atom being written differently for convenience



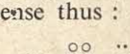
$$\overset{\circ\circ}{\underset{\circ\circ}{{}^{\circ}_{\circ}\text{Cl}\,{}^{\circ}}} + {}_{\times}\overset{\times\times}{\underset{\times\times}{\text{Cl}}}{}^{\times}_{\times} \longrightarrow {}^{\circ}_{\circ}\overset{\circ\circ}{\underset{\circ\circ}{\text{Cl}}}{}^{\circ}_{\times}\overset{\times\times}{\underset{\times\times}{\text{Cl}}}{}^{\times}_{\times}.$$

This type of linkage is known as the normal covalent link ; it is formed between similar atoms, each single link or valency being due to the sharing of two electrons, one from each atom. A dicovalent link results when four electrons are shared in this way. This method of representing the electronic structures of atoms is purely diagrammatic, since no significance is given to the motion of the electrons.

Only the electrons in the outer incomplete groups function as valency electrons. In general, therefore, since 8 electrons constitute a stable outer group it would be expected that the redistribution of electrons in chemical combination would lead to the production of a valency group of 8. This is the basis of the old "octet" theory of valency, and, with some conspicuous exceptions, it is obeyed by most atoms.

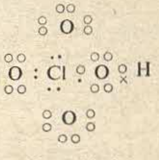
Co-ordinate Covalency

Yet another type of linkage can exist, called co-ordinate covalency, in which both shared electrons come from one atom. For example, hypochlorous acid (HClO) may be written in the electronic sense thus :



$$\text{H}{}^{\times}_{\circ}\overset{\circ\circ}{\underset{\circ\circ}{\text{O}}}{}^{\circ}_{\cdot}\ \overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{Cl}}}:$$

The chlorine now has three pairs of unshared electrons which can function as co-ordinate covalencies with three oxygen atoms, each of which lacks two electrons from its complete octet : thus



$$\begin{array}{c} \overset{\circ\circ}{{}^{\circ}_{\circ}\text{O}{}^{\circ}_{\circ}} \\ {}^{\circ}_{\circ}\overset{\circ\circ}{\underset{\circ\circ}{\text{O}}}:\overset{\cdot\cdot}{\underset{\cdot\cdot}{\text{Cl}}}{}^{\circ}_{\cdot}\overset{\circ\circ}{\underset{\circ\circ}{\text{O}}}{}^{\circ}_{\times}\text{H} \\ \underset{\circ\circ}{{}^{\circ}_{\circ}\text{O}{}^{\circ}_{\circ}} \end{array}$$

In co-ordinate covalent linkages the essentials are that one atom (the "donor") has a lone pair of unshared electrons, and that the other (the "acceptor") has room for two in its octet. Co-ordinate compounds are less stable than normal covalent ones, though they are quite common in organic chemistry.

The question as to how the electrons are shared is of some importance. The combining power of atoms depends on the electrical forces set up by the electronic charges spinning on their own axes. If one electron spin is, as it were, left unneutralised in one atom, it tends to pair off with another unpaired electron in another atom. Both spins are then neutralised by the formation of a chemical linkage.

LESSON 14

Hydrogen: the Lightest Substance Known

HYDROGEN occurs in the free state only in very small quantities upon the earth, but from spectroscopic evidence it appears to exist in enormous quantities in the sun's chromosphere, in certain nebulae and in the atmosphere of some stars. In the combined state it forms one-ninth of the weight of water and is a chief constituent of most organic compounds and all acids. Hydrogen is obtained from three sources—water, acids, and bases. When water containing a little acid or alkali is subjected to the electric current from a battery, bubbles of hydrogen gas appear at the cathode or negative electrode, and oxygen appears at the anode or positive electrode, and the proportions of the gases evolved are two to one.

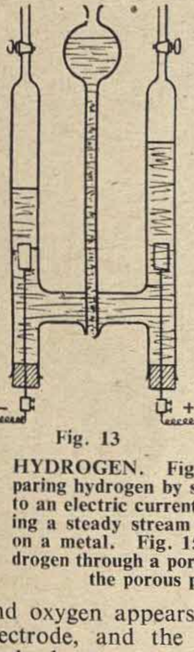


Fig. 13

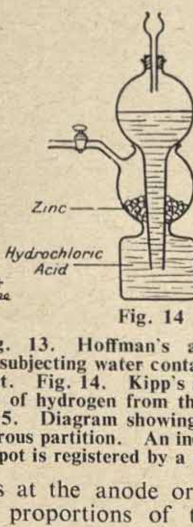


Fig. 14

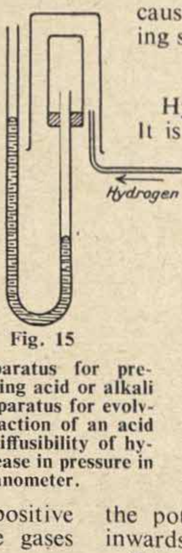


Fig. 15

HYDROGEN. Fig. 13. Hoffman's apparatus for preparing hydrogen by subjecting water containing acid or alkali to an electric current. Fig. 14. Kipp's apparatus for evolving a steady stream of hydrogen from the action of an acid on a metal. Fig. 15. Diagram showing diffusibility of hydrogen through a porous partition. An increase in pressure in the porous pot is registered by a manometer.

Preparation of Hydrogen

To obtain hydrogen the electrodes are put in separate compartments, the most usual arrangement being that designed by Hoffman (Fig. 13). Pure water is a very poor conductor of electricity, so that it is necessary to add a little dilute acid or alkali. With sulphuric acid the reaction may be expressed:

$$H_2SO_4 \rightarrow 2H + SO_4$$

and the SO_4 reacts instantaneously with water thus:

$$SO_4 + H_2O \rightarrow H_2SO_4 + O$$

so that the net effect is the decomposition of the water and the accumulation of acid at the positive electrode.

Hydrogen may also be obtained from water by the action of some metals. Sodium, potassium, and calcium react in the cold: red-hot iron liberates hydrogen from steam. Thus:

$$2Na + 2H_2O \rightarrow 2NaOH + H_2 \text{ (caustic soda)}$$
$$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$$
$$\text{(magnetic iron oxide)}$$

In the laboratory, hydrogen is usually prepared by the action of some acids and bases on certain metals. When zinc and iron are treated with dilute hydrochloric or sulphuric acid, hydrogen is rapidly evolved. For a steady stream, a Kipp's apparatus is used (Fig. 14.) The equation for the reaction between zinc and hydrochloric acid is:

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2 \text{ (zinc chloride)}$$

Zinc and aluminium metals also react with caustic soda, liberating hydrogen and forming sodium zincate or aluminate thus:

$$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$$
$$\text{(sodium zincate)}$$

Hydrogen is a colourless and odourless gas. It is the lightest substance known. Because of its extreme lightness hydrogen has the property of being able to diffuse through a porous partition. This phenomenon can be demonstrated in the apparatus shown in Fig. 15. A pot of unglazed porcelain is connected by means of a cork to a glass U-tube containing a coloured liquid to act as an indicator. The pot is first filled with air, the levels of the liquid in the indicator being the same. The pot is then surrounded with an atmosphere of hydrogen as shown, and the indicator will immediately record an increase in pressure in the pot, showing that hydrogen has diffused inwards through the walls.

Numbers of experiments of this kind were carried out by Thomas Graham (1805–69). He showed that the relative speed of diffusion of gases is inversely proportional to the square roots of their densities.

Properties of Hydrogen

The density of oxygen compared with that of hydrogen is 16, so that the rates of diffusion of hydrogen and oxygen are as $\sqrt{16}$ to $\sqrt{1}$, i.e. 4 : 1. In general, if V is the rate of diffusion and D the density of the gas,

$$V_1 : V_2 = \sqrt{D_2} : \sqrt{D_1}.$$

Chemically, hydrogen is rather inert, but it burns in air or oxygen with a very hot, non-luminous flame. It readily removes oxygen from its compounds, a process which is the reverse of oxidation and is called reduction.

Thus it reduces the oxides of copper, zinc, and iron to the metals, forming water according to the equation :

$$CuO + H_2 \rightarrow Cu + H_2O.$$

Hydrogen has many important industrial applications. Its main use is in the manufacture of ammonia for fertilizers, etc., and to a lesser extent in the process of making oil from coal. An oxy-hydrogen flame is used in welding. Under the influence of certain catalysts hydrogen is used to convert liquid fats, such as whale oil, linseed oil, and other vegetable oils, into solid fats, which can be used for soap and candle-making.

Nascent Hydrogen

Hydrogen exhibits the rather curious phenomenon of being absorbed in large quantities by the metals palladium, platinum, and gold. Palladium, for example, absorbs 860 times its own volume at room temperatures. This occluded hydrogen is much more reactive chemically than the ordinary form, a property which is also possessed by hydrogen when under the influence of high temperatures or an electric discharge. Similarly hydrogen, generated in many reactions, possesses at the moment of its birth, or in the so-called " nascent " state, the characteristics of the active form. For example, gaseous hydrogen, if bubbled through an acid solution of ferric chloride or water containing silver chloride in suspension, produces no effect. But if a piece of zinc is added to the acid solution, the rapid generation of nascent gas reduces the ferric chloride to ferrous chloride and the silver chloride to metallic silver. The extreme reactivity of nascent hydrogen makes it a very important reducing agent.

Hydrogen Equivalent of Metals

The equivalent or combining weight of a substance is the weight which will combine with or displace 1·008 grams of hydrogen or 8·00 grams of oxygen. Hence, for metals which liberate hydrogen from an acid, the hydrogen equivalent, as it is called, can be directly obtained by measuring the weight of gas evolved when a known weight of metal dissolves. In practice it is more convenient to measure accurately the volume of gas, and from a knowledge of its density the weight can be readily calculated. It has been found experimentally that 1 c.c. of hydrogen gas at normal temperature and pressure—" N.T.P." (760 mm. pressure and 0° C.)—weighs 0·0000899 of a gram, and this is used as a basis of the calculation.

The following example will illustrate the method :

0·1 gram of zinc, when dissolved in hydrochloric acid, liberated 34·1 c.c. of hydrogen measured at N.T.P. What is the equivalent weight of zinc ?

Since 1 c.c. of hydrogen weighs 0·0000899 of a gram at N.T.P., then 34·1 c.c. weigh 0·003065.

Hence the weight of zinc which would liberate 1·008 grams of hydrogen is $\frac{1 \cdot 008}{0 \cdot 003065} \times 0 \cdot 1$, which is equal to 32·6.

The equivalent weight of zinc, therefore, is 32·6.

LESSON 15

Oxidation and Reduction

So far the process of oxidation has been regarded as the addition of oxygen to a substance (element or compound) or the removal of hydrogen from it, and reduction as the reverse process. These definitions refer to rather special cases and must now be extended to cover many processes essentially the same in principle although they may not necessarily involve oxygen or hydrogen.

Oxidation is the term applied to all reactions in which the valency of any element towards oxygen (or an equivalent element) is increased or the valency of the element towards hydrogen (or an equivalent element) is reduced. Conversely for reduction. Thus chlorine is produced by hydrochloric acid acting on some oxidising agents. With manganese dioxide the reaction is :

$$4HCl + MnO_2 \rightarrow \underset{\text{(manganous chloride)}}{MnCl_2} + Cl_2 + 2H_2O.$$

The valency of chlorine to hydrogen in hydrogen chloride is 1, in elementary chlorine it is nil ; hence the valency of chlorine to hydrogen has been reduced from 1 to 0. The hydrogen chloride has therefore been oxidised. On the other hand, the valency of manganese to oxygen in manganese dioxide is 2, in manganous chloride it is 1 (since the valency of oxygen to chlorine is 2) ; the valency of manganese to oxygen has been reduced from 2 to 1. so that the manganese has been reduced. It is important to notice in the latter case that since the valency of oxygen to hydrogen is 2, the true valency of manganese in the compound manganese dioxide is 4 and in the compound manganous chloride it is 2.

The cases of the replacement of one halogen by another can be considered in a similar way. For example :

$$2KI + Cl_2 \rightarrow 2KCl + I_2$$

In the compound potassium iodide, the valency of iodine to hydrogen is 1 (since the valency of the metal, potassium, to hydrogen is 1), in elementary iodine it is 0. The valency of iodine to hydrogen has been reduced from 1 to 0 ; potassium iodide has therefore been oxidised. Conversely, chlorine has been reduced.

In the reaction between hydrogen bromide and sulphuric acid, represented by the equation :

$$2HBr + \underset{(H_2O\ SO_3)}{H_2SO_4} \rightarrow SO_2 + Br_2 + 2H_2O$$

the hydrogen bromide has obviously been oxidised to bromine. The sulphuric acid, on the other hand, which may be considered to be a compound of the acidic oxide, sulphur trioxide (SO_3) and water, has been converted into the lower oxide, sulphur dioxide (SO_2), and has therefore been reduced.

It will be noticed in these examples—and, in fact, in all such cases—that the processes of oxidation and reduction always occur together. The terms oxidising agent and reducing agent, therefore, are to some extent arbitrary and dependent on the nature of the particular reaction considered. Thus a substance which is usually an oxidising agent may, if it comes in contact with a sufficiently stronger oxidising agent, function as a reducing agent. For example, both iodine and strong nitric acid are oxidising agents, nitric acid being much the stronger. When these two substances are heated together, this reaction occurs :

$$I_2 + \underset{(5N_2O_5 \cdot H_2O)}{10HNO_3} \rightarrow \underset{(I_2O_5 \cdot H_2O)}{2HIO_3} + 5N_2O_4 + 4H_2O$$

The iodine has been oxidised to iodic acid, the compound formed when iodine pentoxide is added to water ; the nitric acid has been reduced to the lower oxide of nitrogen N_2O_4.

As the structure of the atom is now known, it has been shown that electrons (i.e. negatively charged particles) are removed in the process of oxidation and added in the process of reduction.

When the oxide formed by burning a non-metal in air is dissolved in water, the resulting solution is found to have a sour taste and slightly corrosive properties. The solution is said to contain an acid, the presence of which can be detected by certain substances called indicators. One of the commonest indicators used in chemistry is the organic dye, litmus ; its blue colour turns to red in the presence of an acid.

Since the oxides of the non-metallic elements yield acids on solution in water they are called *acidic oxides*. The following equations give three typical cases :

$$\begin{aligned} CO_2 + H_2O &\rightarrow H_2CO_3 \text{ (carbonic acid)} \\ SO_2 + H_2O &\rightarrow H_2SO_3 \text{ (sulphurous acid)} \\ P_2O_5 + 3H_2O &\rightarrow 2H_3PO_4 \text{ (phosphoric acid).} \end{aligned}$$

The oxides of the metals, on the other hand, have exactly opposite properties and are called *bases*. They are able to remove, or neutralise, the acid properties of an acid, and if soluble in water they restore the blue colour of litmus which has been reddened by acid. When neutralisation takes place, the resulting product is a *salt*, and we have the equation :

$$\text{Base} + \text{Acid} \rightarrow \text{Salt} + \text{Water.}$$

In the case of the formation of common salt ($NaCl$) when hydrochloric acid is neutralised with caustic soda :

$$HCl + NaOH \rightarrow NaCl + H_2O.$$

Bases which are soluble in water form solutions which generally have a burning or caustic taste, and are slippery to the touch. Such bases are called alkalis, e.g. caustic soda, caustic potash, burnt lime, etc. ; the name caustic is applied to the strongest alkalis.

LESSON 16

Alkali Metals and their Compounds

The metals lithium, sodium, potassium, rubidium, and caesium—known as the caustic alkali metals because of the caustic properties of their hydroxides—occur in group 1 of the periodic table. These elements afford an example of the gradation of physical and chemical properties which was shown by Mendeléeff to be associated with a gradual increase in atomic weight. Thus lithium, the lightest of the five, forms the weakest base, caesium the strongest ; also, with the exception of lithium, which in some respects resembles the alkaline earth metals calcium, strontium, and barium, the order of increasing solubility of the salts is the same as that of decreasing atomic weight of the elements. For example, sodium salts are in general more soluble than potassium salts.

Of these five metals, sodium and potassium are the most important ; both occur widely distributed, sodium chiefly in the sea, as rock salt ($NaCl$) and as Chile saltpetre ($NaNo_3$), while potassium occurs as sylvine (KCl) and as carnallite (KCl, $MgCl_2$, $6H_2O$). When an electric current is passed through molten sodium or potassium hydroxide, small globules of metal separate out at the negative pole. This is the basis of the Castner process for the preparation of these metals ; the hydroxide is kept at a temperature of about 320° C., and the oxygen, which escapes at the anode, is prevented from coming into contact with the metal. Both are soft, white, lustrous metals that float on water. They are readily oxidised by the air, and react violently with water according to the equations,

$$2Na + 2H_2O \rightarrow 2NaOH + \overset{\nearrow}{H_2};$$

$$2K + 2H_2O \rightarrow 2KOH + \overset{\nearrow}{H_2}.$$

Hydroxides

Sodium and potassium also react readily with sulphur and the halogens. Sodium and potassium hydroxides—known as caustic soda and caustic potash—are used in the manufacture of soaps. The industrial method for the manufacture of caustic soda is based on the electrolysis of the aqueous solution of the chloride. The first stage of the process is the electrolytic dissociation of the chloride according to the equation,

$$NaCl \rightleftharpoons Na^+ + Cl^-$$

The sodium ions then migrate to the cathode, where they are discharged, and the sodium metal immediately reacts with water thus :

$$2Na + 2H_2O \rightarrow 2NaOH + \overset{\nearrow}{H_2}$$

while the chlorine ions are discharged at the anode. Owing to the tendency of chlorine to react with sodium hydroxide to form the hypochlorite and chlorate care is taken to prevent the gas from diffusing back into the cathodic liquors. Chlorine, which is liberated at the anode in this process, forms a very important by-product.

Carbonates and Bicarbonates

Sodium carbonate occurs naturally as a deposit in certain salt lakes in Egypt and Kenya ; it is also present in the ash obtained from plants growing on the seashore. Potassium carbonate—called potash—was obtained in the same way from the ash of wood used to heat pots ; hence its name, As a result of the importance of these carbonates in such industries as the manufacture of glass and soaps, the natural sources soon proved inadequate. The first commercial method of preparation was invented by the French chemist Nicolas Leblanc (1742–1806) in 1791, and was awarded a prize offered by the Academy of Paris for the best process of converting common salt (sodium chloride) into sodium carbonate. In the first stage of the process sodium chloride is heated with strong sulphuric acid, sodium sulphate and hydrochloric acid being formed according to the equations,

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + \overset{\nearrow}{HCl};$$

$$NaHSO_4 + NaCl \rightarrow Na_2SO_4 + \overset{\nearrow}{HCl}.$$

The sodium sulphate is then mixed with limestone and coke and heated more strongly, when these reactions take place :

$$Na_2SO_4 + 2C \rightarrow Na_2S + 2CO_2;$$
$$Na_2S + CaCO_3 \rightarrow Na_2CO_3 + CaS.$$

The residual black mass—called black ash—containing sodium carbonate and calcium sulphide together with various impurities, is washed with water ; the carbonate dissolves and is obtained from the solution by recrystallisation. In this process considerable importance attaches to the utilisation of the by-products, since they would otherwise be a source of waste ; in fact, it was only by eliminating this waste that the Leblanc process was able to compete with more economical methods. The hydrochloric acid liberated in the first stage is used for the production of chlorine and bleaching powder, and the calcium sulphide obtained in the last stage forms a source of sulphur, which is extracted by the Chance process.

Solvay Soda Process

The Leblanc process has been almost entirely superseded by the ammonia-soda or Solvay process. This method consists in passing carbon dioxide gas, prepared by heating limestone, up a tower down which a solution of brine saturated with ammonia is percolating. Crystals of sodium bicarbonate are deposited on the baffle plates in the tower. The solid bicarbonate is sold as such or converted into the carbonate (soda) by heating. The reactions taking place in this process may be written :

$$NH_4OH + CO_2 \rightleftharpoons \underset{\text{(ammonium bicarbonate)}}{NH_4HCO_3};$$
$$NH_4HCO_3 + NaCl \rightarrow NH_4Cl + NaHCO_3.$$

If carbonate is required :

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

and the CO_2 is available for a further cycle. Also the ammonium chloride, when heated with lime (from the limestone), yields ammonia gas, which is then put through the plant again, so that there are no wasteful by-products.

The process cannot, however, be used for the potassium salt, since potassium bicarbonate is comparatively soluble in water and is not precipitated at the first stage. Potassium carbonate is prepared by the Leblanc process or by passing carbon dioxide into the hydroxide.

In solution, sodium carbonate—washing soda—tends to hydrolyse according to the equation,

$$Na_2CO_3 + H_2O \rightleftharpoons H_2CO_3 + 2NaOH.$$

The solution shows an alkaline reaction owing to the presence of free sodium hydroxide, and it is the detergent action of this free caustic soda which gives to washing soda its cleansing properties.

Sodium bicarbonate readily loses carbon dioxide on heating or on treatment with even weak acids, such as tartaric or citric acid. Baking soda is a mixture of the bicarbonate and cream of tartar (acid potassium tartrate), which in solution yields a certain amount of free acid. The process of baking therefore involves the evolution of carbon dioxide, which forms small bubbles in the dough and causes the pastry to rise.

Copper, Silver, and Gold

In the periodic table it will be seen that these elements are in period IB, indicating a vague chemical resemblance to the alkali metals. Their weakly basic character and inactivity to oxygen, however, contrast with the alkali metals and the similarity exists only in so far as they give rise to a series of univalent salts, e.g. CuCl, AgCl, etc.

Copper occurs naturally as oxide, carbonate, and sulphide : the metal is prepared from oxide and carbonate ores simply by heating with carbon (coke). Sulphide ores present more difficulty owing to the affinity of copper for sulphur. Part of the ore is oxidised in a blast furnace ; the air is then shut off and the copper oxide allowed to react with some more sulphide. The reactions may be written :

$$2Cu_2S + 3O_2 \rightarrow 2Cu_2O + 2SO_2\ ;$$
$$Cu_2S + 2Cu_2O \rightarrow 6Cu + SO_2.$$

This crude copper—called blister copper—is refined electrolytically ; copper sulphate forms the electrolyte, blister copper the anodes, thin sheets of pure electrolytic copper the cathodes. During the electrolysis copper dissolves from the anode and precipitates on the cathode.

Silver occurs usually associated with copper and lead as sulphide, and as chloride ; it is recovered in the process of refinement.

Gold occurs in the free state either in quartz veins or in the gravel of river beds. It is obtained from the ore mechanically—that is, by washing the gravel in a cradle—or chemically, by converting it into a soluble cyanide or chloride. In the cyanide process it is converted into a complex gold sodium cyanide—$NaAu(CN)_2$—by treatment with sodium cyanide ; the gold is recovered by precipitation with zinc or by electrolysis. In the chlorination process the ore is treated with chlorine and the soluble auric chloride, $AuCl_3$, reducing to metallic gold by means of ferrous sulphate.

When a silver halide is exposed to light, it darkens, owing to the formation of metallic silver. In the case of the chloride the reaction may be written :

$$2AgCl \rightarrow 2Ag + Cl_2.$$

This property is made use of in the photographic plate, which consists of a thin film of gelatin containing a fine emulsion of silver bromide. On exposure to light, metallic silver is deposited in thicknesses which depend on the strength of the light. The plate is then treated with a developer which is a reducing agent, such as pyrogallol or potassium ferrous oxalate, and which increases the precipitation of silver in those portions where the reduction has already been started by the light. When the development is sufficiently dense, the plate is immersed in a fixing bath containing "hypo," which dissolves out the residual silver bromide, leaving a deposit of silver of varying thickness scattered throughout the gelatin film. The process of printing is exactly similar, the darkest portions of the negative appearing lightest on the print.

Alkaline Earth Metals

The metals calcium, strontium, and barium show distinct resemblances to the metals of the alkali group, the chief difference being that they are less reactive. Thus the hydroxides of all three metals are soluble in water and their solutions have fairly strong basic properties. For this reason, and because they are found so widely scattered over the earth in the form of naturally occurring carbonate and sulphates, they are called the alkaline earth metals.

As is the case with the alkali metals, the hydroxides of calcium, strontium, and barium show a steady increase in basicity with increasing atomic weight. In contrast to the metals of group IA, however, the alkaline earth metals form many insoluble salts ; the commonest examples are the carbonates, phosphates, and barium sulphate. Moreover, the action of heat on the nitrate is different in the two cases. Sodium and potassium nitrate, when heated, liberate oxygen and form the nitrite ; the nitrates of the alkaline earth metals, on the other hand, break down into the oxide, giving off nitrogen peroxide as well as oxygen, a reaction which brings them into line with the nitrates of the heavy metals.

Preparation of the Metals

The metals were first isolated by the method used for the preparation of the alkali metals, viz. the electrolysis of the solid hydroxide. However the chloride is more readily fusible than the hydroxide, and it therefore forms the electrolyte in the modern processes. Of the three elements, calcium is the only one which has any commercial application, and even in this case it is very limited. In the preparation of calcium, the chloride is kept molten at a temperature of about 780° C., and the metal solidifies on the end of an iron electrode (the cathode) which is slowly raised from the surface of the molten electrolyte.

The metals are silvery white in appearance, react vigorously with water and dilute acids, from which they liberate hydrogen, and on heating combine with hydrogen to form hydrides, nitrogen to form nitrides, the halogens to form halides, sulphur to form sulphides, and carbon to form carbides. The nitrides and carbides are interesting ; on treatment with water they liberate ammonia and acetylene according to the equations,

$$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3 ;$$
$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + \underset{\text{(acetylene)}}{C_2H_2}.$$

The metals also act as reducing agents, and reduce fuming sulphuric acid ($H_2SO_4 . SO_3$) to sulphur and concentrated sulphuric acid (H_2SO_4) to hydrogen sulphide.

Oxides and Hydroxides

On exposure to air or oxygen the metals rapidly tarnish, owing to the formation of a film of oxide. The oxides are also formed when the carbonates are decomposed by heat ; in the case of calcium carbonate the reaction is written :

$$\underset{\text{(limestone)}}{CaCO_3} \rightleftharpoons \underset{\text{(quicklime)}}{CaO} + CO_2$$

and since the reverse reaction is favoured by an increase in pressure (principle of Le Châtelier), the gas must be removed as rapidly as possible. These oxides are white amorphous powders which melt only at extremely high temperatures and dissolve in water to give the hydroxide. The formation of calcium hydroxide (slaked lime) from quicklime is :

$$CaO + H_2O \rightarrow Ca(OH)_2.$$

The hydroxides are strongly basic ; they turn red litmus blue, and react with acids to form salts and water. A solution of slaked lime in water is lime-water ; in the presence of carbon dioxide it turns milky owing to the formation of the insoluble carbonate, a reaction which is used as a test for carbon dioxide.

The Carbonates

Of the three, calcium carbonate is by far the most important. It occurs as amorphous chalk, which is a deposit consisting of the calcareous remains of marine organisms and shells, as irregularly crystalline limestone and marble, and in the definitely crystalline forms known as calcite and aragonite. Calcite, which is found as large, transparent crystals of the hexagonal system, exhibits the phenomenon of double-refraction and is used for polarising light. Limestone and marble are used as a flux in metallurgical processes and in the production of lime used for making mortar and cement.

If carbon dioxide is passed through a solution containing suspended calcium carbonate, the carbonate gradually passes into solution according to the equation,

$$CaCO_3 + CO_2 + H_2O \rightleftharpoons \underset{\text{(calcium bicarbonate)}}{Ca(HCO_3)_2}.$$

The evaporation of the bicarbonate solution leads to the reverse reaction ; carbon dioxide is set free and calcium carbonate reprecipitated. These are the reactions which are responsible for the formation of caves and gorges in limestone districts and for the deposition of limestone in the form of stalactites and stalagmites.

Hard Water

Water containing dissolved salts of calcium and magnesium does not form a lather with soap at all readily. Such water is called hard water. Soap is a sodium or potassium salt of certain fatty acids such as stearic acid; its reaction with hard water leads to the formation of an insoluble calcium or magnesium salt, which is thrown out in the form of a scum. The equation is written :

$$\underset{\text{(soap)}}{\text{sodium stearate}} + \text{calcium bicarbonate}$$
$$\rightarrow$$
$$\text{sodium bicarbonate} + \underset{\text{(scum)}}{\text{calcium stearate}}$$

and since the soap does not lather until all the calcium bicarbonate has been removed as insoluble scum, washing with hard water is wasteful. Hard water causes the furring of kettles, and when used in boilers it leads to the deposition of a thick scale which considerably reduces the efficiency of the boiler. It is therefore a matter of some importance to remove hardness from water.

When the hardness is due to the presence of dissolved calcium bicarbonate, it can be removed by boiling, which liberates carbon dioxide and forms a precipitate of calcium carbonate; it is then known as "temporary" hardness. Temporarily hard water can also be softened by the addition of slaked lime, which reacts according to the equation,

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow \underset{\downarrow}{2CaCo_3} + 2H_2O$$

and the insoluble carbonate can be removed.

If, however, calcium or magnesium sulphate is present, these methods are not effective, and the water is said to be "permanently" hard.

Water Softeners

One method of removing permanent hardness is to add sodium carbonate (washing soda), the lime or magnesia being again precipitated as carbonates according to the reaction:

$$CaSO_4 + Na_2CO_3 \rightarrow \underset{\downarrow}{CaCO_3} + Na_2SO_4$$

hence the use of washing soda in the laundry.

Another important method of softening water is by means of permutite, a complex sodium aluminium silicate belonging to a group of minerals called zeolites. When hard water is filtered through permutite, the calcium and magnesium salts are converted into insoluble silicates and the water is thereby softened. When the permutite becomes ineffective, it can be regenerated by passing a weak solution of sodium chloride through the calcium permutite ; the sodium compound is thereby reformed, and the calcium washed away in the form of the highly soluble calcium chloride.

Mortar is made by mixing slaked lime and sand to a thick paste, with water. The setting is due to the reaction between the lime and the carbon dioxide of the air, which results in the formation of a rigid mass of calcium carbonate. Cement is made by heating a mixture of limestone, clay, and sand until it sinters. The mass is then pulverised, and, when mixed with water, it sets to a hard, stone-like mass due to the formation of calcium aluminium silicates.

Calcium sulphate is found in the form $CaSO_4 . 2H_2O$, known as gypsum. When gypsum is heated to about 120° C., most of the water of crystallisation is driven off, and if the dried solid, which is called plaster of Paris, is moistened with water and allowed to dry, it sets into a firm, alabaster-like mass. Plaster of Paris is frequently used for obtaining casts of statues, etc., and for giving support in various surgical operations.

Barium sulphate is practically insoluble in water and dilute acids ; it is used as a means of detecting a sulphate in qualitative analysis, the procedure being to add barium chloride solution to a solution of the substance suspected of containing sulphate. A white precipitate of barium sulphate is produced.

Magnesium follows beryllium in group IA and stands immediately before calcium, strontium, and barium, to which it shows distinct similarities. Like them, it is a brilliant white metal, which tarnishes in air, liberates hydrogen from water and acids, reduces carbon dioxide to carbon, is divalent, and reacts with the elements to form a nitride, carbide, sulphide, chloride, and so on.

Unlike the hydroxides of calcium, strontium, and barium, however, magnesium hydroxide is comparatively insoluble in water and is only feebly basic. For this reason many magnesium salts are hydrolysed by water, e.g. $MgCl_2$, which, on warming in contact with moist air, is completely decomposed into the oxide. The most important salts of magnesium are the sulphate $MgSO_4 . 7H_2O$, called Epsom salts and used as a purgative; and the complex ammonium phosphate $MgNH_4 . PO_4$, which is insoluble in water and is used as a means of estimating magnesium.

LESSON 17

Mercury, Zinc, Aluminium, and Other Metals

THOUGH also occupying a position in group IIB of the periodic table, zinc, cadmium, and mercury show only a vague chemical similarity to magnesium and the alkaline earth metals of Group IIA. Thus, while the valency of all three metals in their soluble compounds is 2, their oxides are only very weakly basic ; zinc oxide, in fact, is amphoteric. Also, unlike calcium, strontium, and barium, the metals are comparatively stable to oxygen and water.

Zinc and its Salts

Zinc occurs naturally as oxide, carbonate, and sulphide (zinc blende, ZnS), the latter two of which usually contain small amounts of cadmium ; the ore is converted into oxide by roasting in the presence of air, and the oxide is subsequently mixed with powdered coke and heated in retorts. The distilled zinc is purified by re-distillation or by electrolytic deposition. Cadmium is a by-product in zinc extraction ; being more volatile than zinc, it collects in the first fractions which distil from the retorts.

Mercury is found as cinnabar (HgS), and is extracted from the ore by roasting in air or by heating with lime. The metal distils over and condenses as a liquid ; it is purified by washing with dilute nitric acid or by distillation in vacuo. Zinc and mercury react vigorously with mineral acids ; zinc and hydrochloric acid in contact release hydrogen. Contact with a more electro-positive (noble) metal, e.g. copper or platinum, in the presence of an acid causes the zinc to dissolve freely, hydrogen being liberated on the surface of the noble metal. It is on this property that the use of zinc in galvanic cells is based ; the scheme may be represented :

$$\text{Zinc / acid / }\underset{\longrightarrow}{\text{copper}}\text{ or platinum}$$

and the current flows through the acid in the direction of the arrow. The use of zinc to protect iron from corrosion is due to a similar cause ; iron is galvanised with a thin layer of zinc, which on exposure to air forms a protective coating of oxide. Zinc is also used in batteries and in alloys such as brass.

The chemistry of the salts of zinc is chiefly determined by the behaviour of the oxide or hydroxide towards acids and bases. In this respect, the hydroxide exhibits amphoteric properties ; with acids it acts as a base, while with strong bases it reacts as an acid ; thus with caustic soda this reaction takes place :

$$2NaOH + Zn(OH)_2 \rightleftharpoons \underset{\text{(sodium zincate)}}{Na_2ZnO_2} + 2H_2O.$$

Because of the weakness of the hydroxide in its reactions both as an acid and as a base, zinc salts are somewhat unstable and tend to hydrolyse in the presence of water. Dehydration of zinc chloride, for example, leads to the formation of the oxychloride and the liberation of hydrogen chloride, a reaction which explains its use as a soldering flux. The hydrogen chloride dissolves the oxide film from the metal and keeps the surfaces clean. Pure dry zinc chloride can be prepared only by dehydrating the wet salt in a stream of dried hydrogen chloride.

Mercury is the only metal which is liquid at room temperature ; it is silvery white in appearance, very heavy (about 14 times as heavy as water), and a good conductor of heat and electricity. It is stable to air and oxygen, but is rapidly attacked by ozone, the halogens, and nitric acid. It also dissolves certain metals, such as sodium, potassium, zinc, to give an amalgam.

Mercury and its Salts

Mercury gives two series of salts—mercurous, which correspond to the oxide, Hg_2O, and mercuric, which correspond to HgO. It was previously thought that in mercurous salts the valency of mercury was 1 ; this has been shown not to be the case, the ions present in a solution of a mercurous salt being diatomic and divalent, viz. Hg_2^{++}. The chemistry of mercury salts depends on the reaction :

$$Hg^{++} + Hg \rightleftharpoons Hg_2^{++}$$

which indicates that in the presence of metallic mercury, mercuric salts are reduced to mercurous. Thus if mercuric chloride (corrosive sublimate), prepared by subliming mercuric sulphate with sodium chloride, is heated with metallic mercury, mercurous chloride (calomel) is obtained. This reaction is written :

$$HgCl_2 + Hg \rightleftharpoons Hg_2Cl_2 \text{ (calomel)}$$

Boron and Aluminium

The elements boron and aluminium stand at the head of group IIIA and are intermediate in position between the metallic and non-metallic elements of the two short periods. It is to be expected, therefore, that they would show the properties of both metals and non-metals. Boron, in fact, resembles carbon more closely than it does the metals, and is usually classed as a metalloid. Its non-metallic character is shown by the fact that it forms a stable hydride (*cf.* nitrogen and sulphur) and very stable salts called borates, which are analogous to sulphates and phosphates. On the other hand, boron oxide, B_2O_3, which exhibits acidic properties in boric acid and borates, also behaves as a very weak base, forming unstable salts of the type BCl_3.

Aluminium is considerably more basic in its reactions, as is to be expected with increase in atomic weight. Its oxide does, however, exhibit mildly acidic properties (*cf.* zinc), and is therefore amphoteric. Both elements are trivalent in their compounds.

Boron occurs as boric acid (H_3BO_3) and in the form of borates, usually of sodium, potassium, and calcium.

Boric (or " Boracic ") Acid

Boric—or " boracic "—acid, which is the hydrate of B_2O_3, occurs in lagoons surrounding the outlets of natural hot springs in Tuscany. The acid crystallises out as leafy crystals, which are slightly soluble in water and only weakly acid to litmus. The aqueous solution is a mild antiseptic ; when boric acid is heated it loses water, forming tetraboric acid thus :

$$4H_3BO_3 - 5H_2O \rightarrow H_2B_4O_7$$

and on further heating, boron oxide is formed as a glassy mass which is very resistant to heat, thus :

$$2H_3BO_3 - 3H_2O \rightarrow B_2O_3$$

Borax and its Uses

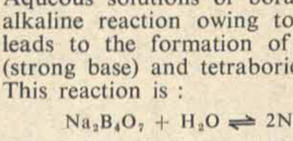
Borax—the sodium salt of tetraboric acid $Na_2B_4O_7$—occurs naturally as tincal, from which it is recovered by recrystallisation. Aqueous solutions of borax show a strongly alkaline reaction owing to hydrolysis, which leads to the formation of sodium hydroxide (strong base) and tetraboric acid (weak acid). This reaction is :

$$Na_2B_4O_7 + H_2O \rightleftharpoons 2NaOH + H_2B_4O_7.$$

When heated, borax behaves in a similar manner to boric acid, producing a certain amount of free boron oxide, which forms a glass-like bead, and if a trace of metallic oxide is fused with it, a complex borate having a characteristic colour is formed. It is upon this reaction that the use of borax in borax-bead testing and in soldering is based.

Aluminium and its Compounds

Owing to its lightness and durability aluminium has important industrial and domestic uses. It is one of the most abundant of the elements, and occurs extensively in the form of oxide, halide, aluminate, and silicate. In the pure form, the oxide, Al_2O_3, occurs as ruby, sapphire, and corundum; in the hydrated form it is found chiefly as bauxite $Al_2O_3.2H_2O$. The metal is obtained by the electrolysis of a solution of purified bauxite in molten cryolite (a double fluoride of



ALUMINIUM FURNACE. Fig. 16. The oxide (bauxite), dissolved in molten cryolite, is reduced by electrolysis in a furnace of the Héroult type. The electrical resistance of the ore produces the necessary heat.

aluminium and sodium, Na_3AlF_6). The cell, shown in Fig. 16, consists of an iron box lined with carbon plates, which act as the cathode ; the anodes are formed by carbon rods, which dip into the molten electrolyte. When the current is passed, liquid aluminium collects at the bottom of the bath, whence it is run off, and carbon dioxide escapes at the anodes.

Aluminium is very light, its density being 2·7 as compared with 7·9 for iron ; it has great tensile strength, fairly high melting point, is a good conductor of heat and electricity and is only slightly attacked by oxygen. In a finely divided form aluminium is an energetic reducing agent, and since a very large amount of heat is evolved in the reduction of some metallic oxides, it is often used in this way to produce the high temperatures necessary for the isolation of certain metals and also for welding *in situ*. The method—the thermite process—is to mix the aluminium powder, a small amount of barium peroxide and the oxide of the metal required, e.g. Fe_2O_3 ; the mass is then ignited by means of magnesium wire, and the heat generated forms the weld.

Aluminium hydroxide—$Al(OH)_3$—formed as a glassy, flocculent precipitate when caustic soda is added to a solution of an aluminium salt, is amphoteric and dissolves in excess of caustic soda to form sodium aluminate. Aluminium hydroxide is used in the dye industry as a mordant, to precipitate the particles of dye and hold them fast in the fabric.

If a strong solution of aluminium sulphate is treated with potassium sulphate and the mixture recrystallised, well-defined crystals of a compound called potash alum, and having the formula $K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$, are formed. A number of similarly constituted salts have been prepared, in which potassium is replaced by sodium or ammonium and aluminium, by a trivalent metal such as iron, manganese, or chromium.

All these alums are isomorphous—i.e. they have the same crystalline form and in aqueous solution give the characteristic reactions of both the univalent and trivalent metals.

LESSON 18

Carbon and its Compounds

THOUGH the element carbon comprises less than 1 per cent. of the materials of the earth's crust, it occurs in very wide distribution. Almost all substances associated with living organisms—whether human, animal, or vegetable—contain carbon combined with other elements. In the early days of chemistry it was believed that these carbon compounds could be obtained only by the agency of living organisms ; they were therefore studied as a separate branch of chemistry called *organic chemistry*, and though it was later shown that many of the compounds of carbon—of which more than 200,000 are known—can be prepared synthetically in the laboratory and, in fact, do not exist in nature, the name " organic " is still retained. Combined carbon is also the main constituent of petroleum, and exists as carbon dioxide in the atmosphere and also as mineral carbonates.

Carbon in the Free State

In the free state carbon occurs in three distinct allotropic modifications : diamond, graphite or black lead, and amorphous carbon. That these three forms are all composed of the same element is readily shown by the fact that equal weights when burnt in oxygen produce exactly the same weights of carbon dioxide in each case. The amounts of heat energy evolved in the burning of an atomic quantity of each are, however, different, as are some of the physical properties, such as hardness, specific gravity, conduction of heat and electricity, etc.

Diamonds are found in the sub-continent of India, South Africa, Brazil, and Australia ; they occur as brittle, extremely hard crystals which belong to the cubic form. They are usually clear and transparent, and derive their peculiar beauty from the very high power of refracting light rays and splitting up ordinary white light into its primary colours.

Real and Artificial Diamonds

The hardness of the diamond gives it practical uses as an instrument for cutting glass and drilling rocks. It is generally supposed that diamonds were formed by the gradual cooling of subterranean pockets of molten carbon when the earth was passing from the plastic to the solid state. Under the enormous pressure of the solid crust and the slow rate of cooling from intense heat, the carbon crystallised as diamond.

This theory has been partly borne out by the work of a French scientist, Henri Moissan (1852–1907), who attempted to make artificial diamonds by dissolving carbon in molten iron at a temperature of about 3,000° C., attained by means of an electric arc furnace. The molten mass was then cooled by plunging it into liquid lead at a temperature over 2,500° lower, thereby causing a high pressure to be exerted on the still molten interior. After dissolving the iron from the kernel some graphite and a few microscopic crystals were found, and though the latter were not actually diamonds they resembled them very closely in appearance and texture.

Graphite

Crystallising in the hexagonal form, graphite, unlike the diamond, is black in appearance. It has a soft, almost soapy touch and is a moderate conductor of heat and electricity. Used for making "lead" pencils, metal polish, and heat-resisting crucibles, and as a lubricant, it is found naturally in Cumberland, Ceylon, California, Siberia. It is prepared by baking powdered coke in an electric furnace at 3,000° C.

Amorphous Carbons

All varieties which are without a definite crystalline structure are amorphous carbons, e.g. coke, wood, charcoal, and lamp-black. Coke, which contains about 90 per cent. of carbon, is obtained by heating coal until the volatile hydrocarbons, some of which constitute the coal gas of commerce, have been driven off. Wood charcoal is formed by the destructive distillation of wood in stacks or retorts. On account of its great porosity this form of carbon has the power of absorbing various gases, fumes, dyestuffs, etc., and for this reason has been widely used in respirators for removing unpleasant odours and poison gases. Another similar type of carbon—called animal charcoal and obtained by distilling bones—has an important use in the removal of dissolved or suspended matter from liquids. Thus, filtration through animal charcoal removes fusel oil from whisky, the colour from sugar syrups, litmus from its solution, and organic matter from drinking water.

Lamp-black is a form of soot obtained by burning organic compounds rich in carbon in a limited supply of oxygen. It is used as a pigment in printer's ink, stove polish, carbon paper, etc.

Carbon Monoxide and Dioxide

Carbon combines fairly readily with oxygen to form two oxides—carbon monoxide (CO), and carbon dioxide (CO_2). Carbon monoxide is formed as a colourless, odourless gas when carbon is burnt in a limited supply of oxygen, or when carbon dioxide is reduced by red-hot coke according to the equation,

$$CO_2 + C \rightleftharpoons 2CO.$$

This process may be observed in a hot coke or coal fire. At the bottom of the fire, where there is an abundant supply of oxygen, carbon dioxide is formed; but as this gas passes upwards through the hot coke it is reduced to carbon monoxide, which burns at the top of the fire with a very hot, blue flame. The gas is present also in the exhaust gases given off by the engines of motor cars; therefore it is dangerous for anyone to stay in a closed garage while an internal-combustion engine is running. The extremely poisonous action of the gas is due to the fact that it forms a compound with the haemoglobin—the red colouring matter of the blood—which prevents the haemoglobin from carrying oxygen from the lungs to the tissues.

In the laboratory, carbon monoxide is obtained by dehydrating formic acid or oxalic acid with strong sulphuric acid. The reactions may be written :

$$\text{(formic acid)}\ H\ CO\ OH - H_2O \rightarrow CO\ ;$$
$$\text{(oxalic acid)}\ H_2C_2O_4 - H_2O \rightarrow CO + CO_2.$$

In the latter case it is usual to pass the gases through a concentrated solution of sodium hydroxide, which absorbs the carbon dioxide.

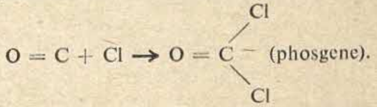
Since carbon occurs in the fourth group of the periodic table, its true valency is 4; in carbon monoxide, written graphically $C = O$, it has a valency of 2.

Carbon Monoxide Compounds

Because of its unsaturated nature, carbon monoxide has the property of combining directly with certain elements, e.g. oxygen, chlorine, and the metals iron and nickel. When passed over hot, finely divided nickel, it forms a compound called nickel carbonyl, thus :

$$Ni + 4\,CO \rightleftharpoons Ni(CO)_4.$$

This substance condenses to a mobile, highly refracting liquid, which boils at 43° C., and on heating decomposes back into nickel and carbon monoxide. This is the basis of the Mond method of purifying nickel. Carbon monoxide also combines directly with chlorine to produce carbonyl chloride or phosgene, a poisonous gas. The equation for its formation is written :



$$O = C + Cl \rightarrow O = C\begin{array}{l} \diagup Cl \\ - \\ \diagdown Cl \end{array} \text{(phosgene).}$$

If a limited supply of air is passed through a thick layer of hot coke, a mixture of nitrogen and carbon monoxide is formed; this is called producer gas and, since carbon monoxide evolves a large amount of heat when it burns, this gas is widely used for heating purposes in industry. If steam is blown through red-hot coke, a mixture of hydrogen and carbon monoxide results :

$$H_2O + C \rightleftharpoons CO + H_2.$$

This is called water gas, also used as an industrial fuel.

If carbon or carbon monoxide is burnt completely in air or oxygen, carbon dioxide is formed, thus :

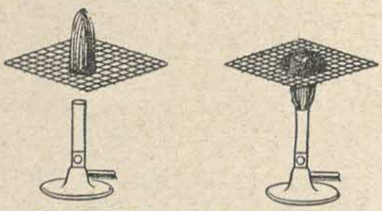
$$C + O_2 \rightarrow CO_2$$
$$2CO + O_2 \rightarrow 2CO_2.$$

The gas is also formed during the process of respiration and in the decay of animal and vegetable matter. It is prepared in large quantities by the action of heat or an acid on carbonates. Thus, if any of the naturally occurring forms of calcium carbonate, e.g. chalk, limestone, and marble, are heated, calcium oxide or lime and carbon dioxide are formed :

$$\underset{\text{(limestone)}}{CaCO_3} \rightarrow \underset{\text{(lime)}}{CaO} + \overset{\nearrow}{CO_2}.$$

Properties of Carbon Dioxide

Carbon dioxide is a colourless, odourless gas with a density about 1½ times that of air ; it does not support combustion, and for this reason it is used as a fire extinguisher. It can be fairly readily liquefied, and when this liquid, which boils at minus 78° C., is allowed to evaporate quickly the absorption of heat is so great that the liquid freezes into a snow-white solid. This carbon dioxide "snow," as it is called, freezes at a much lower temperature than does ice, and it has the additional advantage that, on warming, it passes straight from the solid state into the gaseous state, and does not produce a liquid, as ice does on melting. For this reason it is known as "dry ice," and is used as a refrigerant. Carbon dioxide dissolves in water, especially under high pressures ; so-called aerated and artificial mineral waters are merely aqueous solutions of the gas saturated at pressures of 6–10 atmospheres.



CONTROL OF COMBUSTION. Fig. 17. Flame may be prevented by cooling gas below its ignition point by means of a wire gauze.

The Carbonates

The most important carbonates are sodium carbonate (washing soda), sodium bicarbonate (baking soda), and calcium carbonate, which is used in one form or another in the production of cement and for making lime, which is a component in preparations of whitewash, lime paints, and mortar. The solution of carbon dioxide in water has a feebly acid reaction, presumably through the formation of the acid, carbonic acid, according to the equation,

$$H_2O + CO_2 \rightleftharpoons H_2CO_3.$$

Owing to the readiness with which carbonic acid decomposes into carbon dioxide and water, it has not been isolated in the pure state ; but it gives rise to fairly stable salts, the carbonates. The acid is dibasic, both hydrogen atoms being replaceable. Thus with caustic soda :

$$NaOH + H_2CO_3 \rightleftharpoons \underset{\substack{\text{(sodium bicarbonate}\\ \text{or acid carbonate)}}}{NaHCO_3} + H_2O$$

$$2NaOH + H_2CO_3 \rightleftharpoons \underset{\text{(sodium carbonate)}}{Na_2CO_3} + 2H_2O$$

These salts are hydrolysed in solution and give an alkaline reaction due to the formation of sodium hydroxide.

All carbonates, with the exception of those of sodium, potassium, and ammonium, are insoluble in water. If carbon dioxide is bubbled through lime-water—a solution of slaked lime (calcium hydroxide)—calcium carbonate is formed as a milky-white precipitate :

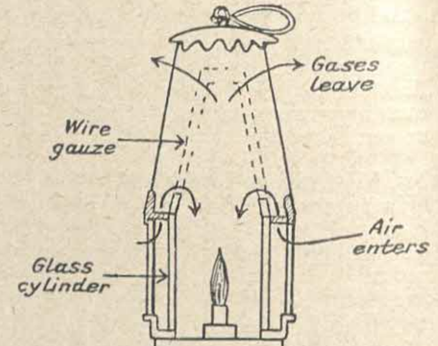
$$Ca(OH)_2 + CO_2 \rightarrow \underset{\searrow}{CaCO_3} + H_2O.$$

This reaction is used as a test for carbon dioxide.

Combustion and Flame

It was shown in Lesson 3 that combustion is merely a process of oxidation accompanied by the development of light and heat, and that in many cases it is necessary to heat the materials up to a certain temperature before the phenomenon of combustion actually starts. This temperature is called the *ignition point* or *flash point* of the substance ; once combustion has started the heat evolved by the burning substance is sufficient to keep the temperature considerably above the ignition point and the process goes on continuously. If, on the other hand, the substance is cooled sufficiently, the combustion may be made to stop. This can be shown in a very simple way (*see* Fig. 17).

If a wire gauze is held about an inch and a half above an open gas burner, and a light applied to the gas above the gauze, it is found that the flame burns above the gauze only. This is because the gauze conducts the heat away so quickly that the temperature of the gas below



MINER'S SAFETY LAMP. Fig. 18. The products of combustion are cooled by the wire gauze surrounding the flame.

the gauze is kept below the ignition point. Only when the wire becomes quite hot does the flame spread to the mouth of the burner. This is the principle of the miner's safety lamp invented by Sir Humphry Davy (1778–1829) and shown in Fig. 18. All the air holes to the flame are protected by wire gauze, and although the combustible gases can pass in and burn inside the lamp, the flame cannot pass through the gauze and be communicated to the explosive mixture of fire-damp and air present in the mine.

The element silicon belongs to the fourth group of the periodic table and comes immediately after carbon, to which it bears a very close chemical resemblance. This is especially noticeable in the case of the oxides—SiO_2 (silicon dioxide or silica) and CO_2. Thus, like CO_2, which is found widely distributed as carbonates of calcium and sodium, SiO_2 occurs abundantly in the form of silicates of calcium, sodium, potassium, and aluminium.

Silica and Silicates

Silica also occurs in the free state as flint, opal, amethyst, quartz or rock crystal, and sand.

Silica is comparatively unreactive chemically ; it is weakly acidic in character, and when boiled with strong bases, e.g. the caustic alkalis, it forms silicates. Because of its non-volatile character it is able to displace most of the other acidic oxides from their salts.

$$Na_2CO_3 + SiO_2 \rightarrow \underset{\text{(sodium silicate)}}{Na_2SiO_3} + CO_2$$

Sodium silicate is known commercially as waterglass and on treatment with a dilute acid it forms a gelatinous precipitate of silicic acid, thus :

$$Na_2SiO_3 + 2HCl \rightarrow 2NaCl + \underset{\text{(silicic acid)}}{H_2SiO_3}$$

Silicic acid gradually sets into a hard, glassy substance which is a hydrated form of silica ; hence the use of waterglass as an egg preservative, for finishing off concrete work, and for adhesives. If a sodium silicate solution is poured slowly into concentrated hydrochloric acid, silicic acid does not separate out, but remains in colloidal solution in the hydrosol form.

Glass is a complex silicate made by fusing together such bases as lime, lead oxide, sodium, or potassium oxide with sand or silica. Ordinary soft or soda glass is a mixture of sodium and calcium silicates. It is coloured by the addition of various metallic oxides ; for example, cobalt oxide gives a blue colour, finely-divided gold or copper a ruby-red, calcium phosphate a white, iron oxide a bottle-green. If the lime is replaced by lead oxide, the glass obtained has a high metallic lustre and is used to make cut-glass vessels. The addition of a potash gives a much harder glass, known as Bohemian glass ; if a portion of the silica is replaced by boric oxide, the very hard borosilicate glass is obtained. This has a higher melting point than potash glass and it can withstand changes of temperature without cracking. It is used for making lenses, and under trade names has been developed in England and the United States for making baking dishes and laboratory ware.

LESSON 19

Tin and Lead

REFERENCE to the periodic table shows that the elements carbon and silicon, which occur in group IV, are connected, on the one hand, to titanium, zirconium, and thorium, and, on the other, to germanium, tin, and lead. Except that they all exhibit a maximum valency of 4—the typical group oxide being MO_2 and the chloride MCl_4—there does not appear to be much chemical similarity between the non-metallic elements at the head of the groups and the well-defined metals which follow.

Atomic Weight and Basic Properties

As has been mentioned, an *increase in atomic weight in any group* of the table leads to a gradual development of basic—that is, metallic—properties, and this is well exemplified in group IV. Thus germanium (atomic weight 72), though a metal, has properties which are suggestive of carbon and silicon ; both of its oxides, for example, are amphoteric, while tin (119) and lead (207) show increasingly pronounced basic properties. Thoria, the oxide of thorium (atomic weight 232), is purely basic in its reactions.

Tin occurs as cassiterite—SnO_2—in Cornwall, the Malay Peninsula, Australia, Indonesia, and Germany. The ore is roasted, to oxidise the sulphides of iron with which it is frequently associated and to remove arsenic. It is sometimes freed from iron and tungsten in a magnetic separator, and then mixed with carbon (coal) and heated strongly in a reverberatory furnace, where the oxide is reduced to the metal, which is run off.

Tin is a lustrous, white metal intermediate in hardness between zinc and lead ; it is very ductile and malleable and can be beaten into thin foil. Because of its resistance to corrosion it is in great demand for the manufacture of tinplate articles, which are made of steel or copper dipped in molten tin. Alloys of tin are used commercially—for example, bronze (tin, zinc, copper, and lead), pewter (tin and lead), gunmetal, and bell-metal; most alloys with low melting points, e.g. solder and type metal, contain tin and lead in varying proportions.

Like carbon, tin exists in three allotropic modifications, two of which, the rhombic and tetragonal forms, are crystalline, and the third, called grey tin, amorphous. The last is obtained by cooling the crystalline forms well below 18° C. The crystalline structure of the metal at ordinary temperatures is apparent to the eye; the curious sound emitted when a bar of tin is bent —called " tin cry "—is supposed to be due to the rubbing of the crystals against one another.

Tin has two valencies, two and four, and gives rise to two well-defined series of salts. The divalent or stannous compounds are generally salt-like in character, and since in solution they tend to pass over into the quadrivalent stannic form they are fairly strong reducing agents.

Stannous and Stannic Salts

Stannous chloride and sulphate, both of which are white crystalline solids, are prepared by the action on tin of hydrochloric acid and hot sulphuric acid respectively. Thus :

$$\mathrm{Sn} + 2\mathrm{HCl} \rightarrow \mathrm{SnCl_2} + \mathrm{H_2};$$
$$\mathrm{Sn} + 2\mathrm{H_2SO_4} \rightarrow \mathrm{SnSO_4} + \mathrm{SO_2} + 2\mathrm{H_2O}.$$

Stannous chloride is used in solution as a reducing agent. It precipitates silver and gold from solutions of their salts, reduces chromates to chromic salts and mercuric chloride, first, to mercurous chloride and finally, if present in excess, to metallic mercury. This latter reaction is used in qualitative analysis as a test for tin and for mercury. The equations are written :

$$\mathrm{SnCl_2} + 2\mathrm{HgCl_2} \rightarrow \mathrm{SnCl_4} + 2\mathrm{HgCl};$$
$$\mathrm{SnCl_2} + 2\mathrm{HgCl} \rightarrow \mathrm{SnCl_4} + 2\mathrm{Hg}.$$

Stannic salts tend to hydrolyse in the presence of water, and in general cannot be prepared in solution. The chloride—$SnCl_4$—is obtained as a fuming liquid (boiling point 114° C.) when dry chlorine is passed over heated tin or stannous chloride. Both series of salts react with an alkali to give a precipitate of the appropriate hydroxide. As is the case with aluminium and zinc, these hydroxides are amphoteric and dissolve in excess of caustic alkali to form stannites (stannous) and stannates (stannic).

Stannates (Quadrivalent) Compounds

The reaction in the latter case is written :

$$\mathrm{Sn(OH)_4} + 2\mathrm{NaOH} \rightarrow \underset{\text{(sodium stannate)}}{\mathrm{Na_2SnO_3}} + 3\mathrm{H_2O}.$$

Stannates therefore appear to be the salts of H_2SnO_3—meta-stannic acid—which is obtained by the partial dehydration of $Sn(OH)_4$. Meta-stannic acid is also formed when tin dissolves in hot concentrated nitric acid, thus :

$$\mathrm{Sn} + 4\mathrm{HNO_3} \rightarrow \mathrm{SnO_2}.\ \mathrm{H_2O} + 4\mathrm{NO_2} + \mathrm{H_2O}.$$

When strongly heated, the acid is completely dehydrated, giving finally a white powdery residue of stannic oxide—SnO_2.

Both sulphides are prepared by the direct union of tin and sulphur or by passing sulphuretted hydrogen through a solution of the appropriate salt. Stannic sulphide—which is bright yellow in colour—dissolves readily in caustic soda or ammonium sulphide solution ; the reaction

$$\mathrm{SnS_2} + \mathrm{(NH_4)_2S} \rightarrow \underset{\text{(ammonium thiostannate)}}{\mathrm{(NH_4)_2SnS_3}}$$

is similar in nature to that which occurs when the oxide dissolves in caustic soda. It is used in qualitative analysis as a means of separating tin from the other metals.

Lead and its Alloys

Lead occurs chiefly as galena, an impure form of lead sulphide, which often contains small traces of silver. The ore is roasted until the sulphide has been converted into oxide or sulphate, and then mixed with more galena and heated with the air shut off. Sulphur dioxide is liberated, and the lead collects at the bottom of the furnace. Lead is a soft, dense, bluish-grey metal, which tarnishes rapidly in air owing to the formation of a film of oxide but is otherwise comparatively unreactive. It has a low melting point (326° C.), is very malleable and ductile and is therefore used in the form of sheets for lining reaction chambers, e.g. in the sulphuric acid process, and in the construction of water pipes, etc. Alloys of lead are also of considerable importance ; these include pewter, type metal, and solder.

Lead Salts

Like tin, lead has valencies of 2 and 4, and it forms two series of salts corresponding to the oxides PbO and PbO_2. Lead monoxide, or litharge, is formed as a buff-coloured or yellowish-red powder when the metal is heated in air ; it is also obtained by the action of heat on lead nitrate or carbonate, and by boiling white lead hydroxide, which is precipitated when an alkali is added to the solution of a lead salt. Lead hydroxide—$Pb(OH)_2$—is a stronger base than stannous hydroxide, although it still exhibits mildly amphoteric properties and dissolves in caustic soda to form an unstable plumbite, thus :

$$\mathrm{Pb(OH)_2} + 2\mathrm{NaOH} \rightleftharpoons \mathrm{Na_2PbO_2}.$$

Litharge dissolves fairly readily in acids, giving rise to divalent lead salts ; when heated in air to about 400°-500° C. it turns red, owing to the formation of the oxide—Pb_3O_4—called red lead, which is used in the manufacture of flint and pottery glasses and as a paint.

Lead dioxide—PbO_2—is prepared by the action of strong oxidising agents on an alkaline solution of lead hydroxide. It is also prepared by anodic oxidation in the electrolysis of lead salts. It is insoluble in water, is a strong oxidising agent, and reacts with caustic soda to form a meta-plumbate (*cf.* meta-stannates). As with tin, the quadrivalent compounds of lead are unsaltlike in appearance, and in the presence of water hydrolyse completely to form lead dioxide. Lead differs from tin in the insolubility of its halides and sulphate, and also in the fact that divalent lead compounds have no reducing properties.

When sodium carbonate is added to the solution of a lead salt, a heavy white precipitate of *basic lead carbonate* is formed. This is white lead, $2PbCO_3 . Pb(OH)_2$, in great demand as a pigment. In the old Dutch stack process lead sheets on earthenware pots containing dilute acetic acid are arranged on tiers of spent tan bark, which provide the carbon dioxide and heat necessary ; after three to four months white lead is produced. In the modern process sheets of lead are hung in a room, at a temperature of about 70° C., carbon dioxide and acetic acid vapour being admitted.

When dilute sulphuric acid is electrolysed between lead electrodes, the oxygen which is set free by the discharge of SO_4 ions oxidises the anodic lead to lead dioxide, which forms a dark brown spongy deposit on the anode. When the electrolysis is stopped, it is found that the cell so formed—

$$\underset{\longrightarrow}{Pb \;/\; H_2SO_4 \;/\; PbO_2}$$

—produces a steady and fairly strong electric current. This is the basis of the lead accumulator; the mechanism of the discharge process is indicated by the equations,

$$\begin{array}{r}
Pb + SO_4^{--} \rightarrow PbSO_4 + 2\ominus \\
PbO_2 + 4H^+ + SO_4^{--} \rightarrow PbSO_4 + 2H_2O + 2\oplus.
\end{array}$$

The lead acts as the cathode, the lead dioxide as the anode, and the current passes through the cell in the direction indicated by the arrow above. While the cell is discharging, both plates become gradually coated with lead sulphate and the flow of current ultimately ceases. The system may then be recharged by passing a current through the cell in the opposite direction, when the lead/lead dioxide plates are re-formed. The whole process, which is thus a reversible one, is summarised in the following equations :

$$Pb \;/\; H_2SO_4 \;/\; PbO_2 \rightleftharpoons PbSO_4 \;\Big/\; \begin{array}{c} H_2O \\ + \\ H_2SO_4 \end{array} \Big/ \; PbSO_4$$

$$\underset{\text{discharge}}{\longrightarrow} \qquad\qquad \underset{\text{recharge}}{\longleftarrow}$$

LESSON 20

The Atmosphere

The envelope of air which surrounds the earth is called the atmosphere. The experiments of Lavoisier on the elementary nature of the air proved that it is chiefly a mixture of the two gases nitrogen and oxygen, mixed in the volume ratio of approximately 4 to 1. As might be expected, the air also contains other gases, most of which are formed in chemical reactions taking place on the earth's surface. Carbon dioxide, formed in the burning of wood, coal, and oil, in the respiration of animal life, and in fermentation and putrefaction processes, occurs in small amounts ; ozone and oxides of nitrogen are produced in electrical disturbances ; ammonia, hydrogen, and hydrocarbons such as methane, result from organic decomposition ; and there are also varying quantities of dust particles and water vapour.

Inert (or Rare) Gases

In addition to those mentioned, the atmosphere contains small traces of a number of other gases, the presence of which was first suggested by the experiments of Henry Cavendish (1731–1810). Cavendish found that if electric sparks were passed through air, and the nitrogen dioxide which resulted from the combination of the nitrogen and oxygen was absorbed in dilute alkali, a small bubble of gas—about 1/120 of the original volume—remained behind. In 1893 Lord Rayleigh (1842–1919) showed that nitrogen obtained from the air by removal of oxygen was 1 part in 200 heavier than an equal volume of nitrogen prepared by chemical means. It seemed probable, therefore, that atmospheric nitrogen contained small quantities of a heavier gas. In 1894 Sir William Ramsay (1852–1916) isolated the new gas by causing the nitrogen to combine with heated magnesium metal. It was found to be denser than nitrogen and, as it showed a complete lack of reactivity towards other elements, it was called *argon*, the word meaning in Greek idle, inert. In the course of further experiments on argon Ramsay found that there were four other gases present in the atmosphere in small traces. These were called *helium* (atomic weight 4), *neon* (20), *krypton* (83·7), and *xenon* (131·3), and as they all showed the same chemical inertness as argon they were called the inert or rare gases.

Helium derived its name (Greek *helios*, sun) from the substance observed spectroscopically in the sun's chromosphere, and this gas was later shown to be present in certain rare minerals and the waters of some mineral springs. These are the main sources of helium, and it is known that in both cases it is produced by radioactive disintegration. Owing to its lightness and non-inflammability it is used to fill balloons and airships.

Neon constitutes only about 1 part in 80,000 of the air, but it is of considerable industrial importance. Electric discharges pass very readily through the gas, which then emits a bright orange-red glow. For this reason it is used for low-powered electric lamps and for electric advertisement signs. Neon is obtained from liquid air.

Nitrogen

About four-fifths of the air by volume is composed of nitrogen, which is readily obtained from it either by chemical or by physical means. If air is passed over some such reducing agent as phosphorus or heated copper, the oxygen is removed according to the equation,

$$2Cu + O_2 \rightarrow 2CuO$$

and the nitrogen is left behind. A much simpler method is to liquefy the air, letting the more volatile nitrogen evaporate first.

To bring about the liquefaction of the less condensable gases, a low temperature is necessary as well as a high pressure. In the process invented by Georges Claude (b. 1870) the low temperature is obtained by allowing the compressed air to expand; at the moment of expansion energy is supplied by the gas in overcoming the forces of cohesion between the molecules, and the air therefore cools itself. This cooled air is then allowed to cool the compressed air. The effect is cumulative and continuous, and the temperature of the air finally becomes sufficiently low to cause it to liquefy. Nitrogen obtained from the air by these methods contains small amounts of various impurities. Pure nitrogen is prepared chemically by the action of heat on ammonium nitrite or a mixture of ammonium chloride and sodium nitrite. The reaction is written:

$$NH_4NO_2 \rightarrow N_2 + 2H_2O$$

Nitrides, Ammonia, and Nitric Oxide

Nitrogen—called by Lavoisier "azote" (Greek *a-*, not; *zoe*, life)—is very inert. It extinguishes a glowing splint, and at ordinary temperatures it is practically indifferent to all elements. Under the influence of heat, however, it combines with many metals to form nitrides, e.g. magnesium, lithium, calcium, iron; and under the influence of the electric spark it combines with hydrogen to form ammonia and with oxygen to form nitric oxide.

Nitrogen unites directly with hydrogen when a mixture of the two gases is subjected to an electric discharge, but the reaction appears to cease when about 2 per cent. of ammonia has been formed. It is essential, therefore, to absorb the ammonia as fast as it is formed, either in water or an acid, and the reversible reaction

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

can then go to completion in the forward direction. Hydrogen and nitrogen also combine under the catalytic influence of finely divided metals. Since the reaction leads to a decrease in volume by one-half, the amount of ammonia formed is increased if the pressure is raised, in accordance with the principle of Le Châtelier. Most of the ammonia of commerce is obtained as a by-product in the manufacture of coal gas by the destructive distillation of coal. The gas is washed with water, in which the ammonia is freely soluble; the ammoniacal liquid is boiled with milk of lime and the ammonia absorbed in water to form "aqua ammonia," or in acid, where it is converted into ammonium salts.

Ammonia is prepared in the laboratory by heating any of its salts with caustic soda or lime. The reaction is written:

$$NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3.$$

Properties of Ammonia

A colourless gas with a pungent odour, ammonia is extremely soluble in water. It can be readily liquefied, and when the liquid evaporates it absorbs a very large amount of heat. At $-33°$ C., 17 grams of liquid ammonia require 5·7 kg. cals. for conversion into gas. Because of this property ammonia is used as a refrigerant, the gas being alternately compressed and rarefied much as in the method of preparation of liquid air.

The most striking chemical property of ammonia is the basic character of its aqueous solution, due to the formation of ammonium hydroxide:

$$NH_3 + H_2O \rightleftharpoons NH_4OH.$$

This solution turns red litmus blue and reacts with acids to form salts and water. Thus with hydrochloric acid this reaction takes place:

$$\begin{gathered} NH_4OH + HCl \rightarrow NH_4Cl + H_2O \\ \text{(base + acid} \rightarrow \text{salt + water)} \end{gathered}$$

Ammonia also reacts with hydrogen chloride gas to produce dense white fumes of solid ammonium chloride:

$$NH_3 + HCl \rightarrow NH_4Cl.$$

This is used as a test for ammonia.

Three volumes of hydrogen combine with 1 volume of nitrogen to produce 2 volumes of ammonia. By Avogadro's hypothesis, the number of molecules which combine are in the same ratio. It follows, therefore, that:

$$3H_2 + N_2 \rightleftharpoons 2NH_3$$

and since the vapour density of ammonia is 17 ($H_2 = 2$), the formula is NH_3.

LESSON 21

The Oxides of Nitrogen

NITROGEN exhibits the unusual property of combining with oxygen in five different proportions. Two of these oxides—the trioxide and the pentoxide—dissolve in water to form acids, which give rise to the two well-defined series of salts called nitrites and nitrates.

The oxides are :

Nitrous oxide	N_2O
Nitric oxide	NO
Nitrogen trioxide	N_2O_3 giving nitrous acid HNO_2
Nitrogen peroxide (tetroxide)	N_2O_4
Nitrogen pentoxide	N_2O_5 giving nitric acid HNO_3

Of the acids, nitric acid is much stronger than nitrous, while nitrates are more stable than nitrites. This illustrates a general principle concerning oxides : as the oxygen content of the oxide increases the acidic properties also increase, and the stronger the acid the more stable are its salts.

Nitrous Oxide and Nitric Oxide

Nitrous oxide is formed when dry ammonium nitrate is heated in a flask to about 200° C. The reaction may be written :

$$NH_4NO_3 \rightarrow N_2O + 2H_2O.$$

It is also prepared by the reduction of nitric acid with a fairly vigorous reducing agent, such as stannous chloride. With hydrochloric acid present the reaction is :

$$2HNO_3 + \underset{\text{(stannous chloride)}}{4SnCl_2} + 8HCl \rightarrow 4SnCl_4 + 5H_2O + N_2O$$

Nitrous oxide is a colourless gas, fairly soluble in water. It supports combustion in much the same way as oxygen does ; a glowing splint bursts into flame when plunged into the gas. Nitrous oxide is used as an anaesthetic (" laughing gas ") for minor surgical operations and, mixed with oxygen, for more prolonged anaesthesia.

Nitric oxide is formed when an electric spark is passed through a mixture of nitrogen and oxygen. This is the first step in one of the methods of fixation of atmospheric nitrogen ; but as the nitric oxide immediately combines with oxygen to form nitrogen peroxide, it cannot be prepared in the pure state by this means. It is usually prepared in the laboratory by nitric acid acting on a mild reducing agent, such as metallic copper or ferrous sulphate. With copper the equation is :

$$8HNO_3 + 3Cu \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O.$$

Nitric oxide is a colourless gas, which, when mixed with air or oxygen, produces reddish-brown fumes of nitrogen peroxide ; its most important chemical property is that it dissolves in ferrous sulphate solution to form a brown compound, which is the distinguishing feature of the *brown ring test for nitrates*. Concentrated ferrous sulphate solution is added to a solution of the substance to be tested and strong sulphuric acid is gently poured into the mixture : if a nitrate is present, nitric acid is formed and is reduced to nitric oxide, which gives a brown ring with the ferrous sulphate.

Nitrous Acid and Nitrites

Nitrogen trioxide is comparatively unstable, but the acid which corresponds to its solution in water gives rise to an important series of salts called nitrites. Nitrites of the alkali metals are prepared by heating the nitrates either alone or with metallic lead (reducing agent). The equation for the reaction is:

$$Pb + NaNO_3 \rightarrow PbO + \underset{\text{(sodium nitrite)}}{NaNO_2}$$

They are also formed together with nitrates, as in the fixation of atmospheric nitrogen, when nitrogen peroxide is absorbed in caustic soda or potash. Thus :

$$2NaOH + N_2O_4 \rightarrow NaNO_2 + NaNO_3 + H_2O.$$

Nitrous acid is very unstable, and exists only in dilute solution. Since nitrous acid and nitrites are reduction products of nitric acid they react as mild reducing agents. For example, in acid solution they decolorise potassium permanganate, and are themselves converted to nitric acid or nitrates, according to the equation :

$$5NaNO_2 + 2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 5NaNO_3 + 2MnSO_4 + 3H_2O.$$

Nitrogen peroxide is formed in the second stage of the fixation process by the oxidation of nitric oxide :

$$2NO + O_2 \rightarrow N_2O_4.$$

It is also formed when the nitrates of the heavy metals, such as copper, are decomposed by heat, or by the reduction of nitric acid with arsenious oxide.

At ordinary temperatures nitrogen peroxide is a heavy yellow gas ; at a temperature of about 140° C. it has a reddish brown colour due to dissociation according to the equation :

$$\underset{\text{(yellow)}}{N_2O_4} \rightleftharpoons \underset{\text{(deep brown)}}{2NO_2}$$

At higher temperatures it decomposes into $2NO + O_2$.

Nitric Acid and Nitrates

Nitric acid is the most important oxy-compound of nitrogen. It occurs naturally in the form of sodium nitrate (Chile saltpetre), enormous quantities of which are found in the desert regions of the west coast of South America, and as potassium and calcium nitrate in the sub-continents of India and Arabia. The calcium salt is converted into potassium nitrate by treatment with potassium carbonate :

$$Ca(NO_3)_2 + K_2CO_3 \rightarrow CaCO_3 + 2KNO_3.$$

Nitric acid is manufactured on a large scale by heating a mixture of a nitrate and sulphuric acid in iron retorts. The more volatile nitric acid is driven off according to the equation,

$$2NaNO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2HNO_3.$$

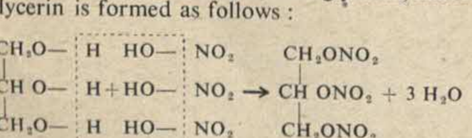
It is also prepared commercially in the final stage of the processes of fixation of atmospheric nitrogen.

Nitric acid is a colourless liquid, which is very soluble in water, giving a solution of extremely corrosive properties. It is a powerful oxidising agent, converting iodine to iodic acid, phosphorus to phosphoric acid, and sulphur to sulphuric acid ; and reacting violently with organic matter. In most cases it is itself reduced to nitrogen peroxide. It attacks most metals vigorously, and for this reason was called aqua fortis. The products of the reactions with metals depend mainly on the temperature and the strength of the acid ; in general, nitric oxide or nitrogen peroxide are evolved, but with metals which are strong reducing agents, e.g. tin, the acid is sometimes reduced even to ammonia.

Nitric acid reacts with bases to form stable salts called nitrates. Of these, the alkali nitrates are the most important and they are used as fertilizers and in the manufacture of explosives.

Gunpowder and Explosives

Owing to the ease with which nitric acid and nitrates can be made to part with oxygen they are vigorous promoters of combustion. For this reason they are used in the manufacture of explosives. Gunpowder is a mixture of about 75 per cent. of potassium nitrate, 10 per cent. of sulphur, and 15 per cent. of charcoal. The explosion is caused by the sudden liberation of a large volume of gas brought about by the rapid oxidation of the carbon and sulphur. Nitric acid is also used in the production of another form of explosive, in which the process of oxidation takes place within the molecule, and not externally, as is the case with gunpowder. Thus, when nitric acid is added to some organic substances—particularly if concentrated sulphuric acid is also present to absorb the water formed—a nitro-compound is produced. For example, with glycerin, nitroglycerin is formed as follows :



$$\begin{array}{lll} CH_2O-H & HO-NO_2 & CH_2ONO_2 \\ | & & | \\ CH\ O-H & +HO-NO_2 \rightarrow & CH\ ONO_2 + 3H_2O \\ | & & | \\ CH_2O-H & HO-NO_2 & CH_2ONO_2 \end{array}$$

Similarly, phenol gives trinitrophenol or picric acid, the active explosive in melinite ; toluol gives trinitrotoluol (T.N.T.) : cellulose gives nitrocellulose or guncotton, the active agent in cordite.

Nitrogen is one of the most important elements ; it is a constituent of all forms of tissue associated with living organisms, both animal and vegetable. The animal kingdom cannot assimilate free nitrogen, and accordingly depends for its supply upon the nitrogenous matter present in plants.

Some plants—the Leguminosae (peas, beans, clover, lupin, etc.)—are able, with the aid of certain bacteria present in their roots, to assimilate the free nitrogen of the air. But for most plants the nitrogen must be in the form of a nitrate of an ammonium salt before it can serve as a plant food. Small amounts of these substances are produced in the soil by the action of nitrifying bacteria.

Fixation of Atmospheric Nitrogen

Because of the danger of exhaustion of the large natural sources of nitrates, three methods have been developed to " fix " the stores of nitrogen present in the atmosphere. The first of these depends on the direct oxidation of the nitrogen of the air under the influence of an electric arc. At the temperature of the arc about 10 per cent. of nitric oxide is formed, and since the tendency of the gas to dissociate into its elements is high at high temperature, it is essential that the gas should be cooled immediately after it has been formed. In the Birkeland and Eyde furnace the electrodes consist of copper tubes through which water circulates, and the arc is spread by means of a strong magnetic field into two semicircular discs of flame at right angles to the axis of the electrodes. The gases containing the nitric oxide are swept out of the flame into an oxidation chamber, where the reaction

$$2NO + O_2 \rightarrow 2NO_2$$

takes place. The NO_2 is then absorbed in sodium or calcium hydroxide, giving a mixture of nitrite and nitrate.

In the other methods the nitrogen is converted into ammonia either by direct synthesis with hydrogen by the Haber process, or by the action of water on calcium cyanamide (nitrolime) obtained by forcing nitrogen at a temperature of about 800° C. into a retort filled with calcium carbide. This reaction takes place :

$$\underset{\text{(calcium cyanamide)}}{CaCN_2} + H_2O \rightarrow CaCO_3 + 2NH_3.$$

The ammonia is then converted into ammonium salt or catalytically oxidised to nitric acid thus :

$$NH_3 + 2O_2 \rightarrow HNO_3 + H_2O.$$

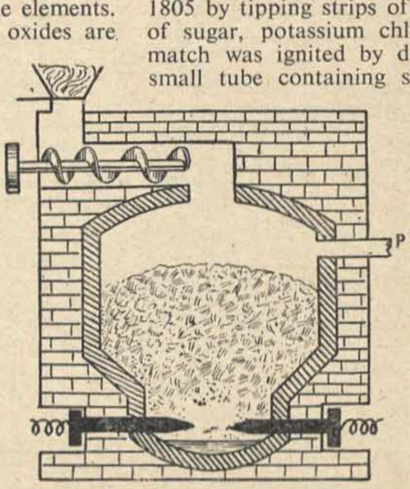
By the Haber ammonia process about a million tons of nitrogen are fixed in the form of ammonia compounds every year.

LESSON 22

Phosphorus, Arsenic, Antimony, Bismuth

NITROGEN is at the head of group VB. It is followed in that group by the elements phosphorus, arsenic, antimony, and bismuth, all of which possess a maximum valency of 5 and show the strong family relationships common to elements occurring in the same group. There is, however, the same gradual transition of properties, which is a general characteristic of the periodic table and which has been shown to be associated with a gradual increase in the atomic weight of the elements. Thus nitrogen is a non-metal—its oxides are strongly acid-forming ; bismuth is metallic in nature—its oxides are mildly basic ; the intermediate elements, arsenic and antimony, exhibit both non-metallic and metallic properties.

Phosphorus occurs widely, generally in the form of phosphates. These occur in large masses as phosphatic rock, in the bones of animals, and in the guano (the accumulated excrement of sea birds). The element is obtained from native mineral phosphate or from bone ash, the residue—mainly calcium phosphate—left when bones are burnt. In the modern electrical process a mixture of phosphate, silica (sand), and coke is heated to a very high temperature in an electric resistance furnace of the type shown in Fig. 19. The silica, being the less volatile oxide, displaces the phosphoric oxide, which is subsequently reduced by the coke.



PREPARATION OF PHOSPHORUS. Fig. 19. From bone ash by means of an electric resistance furnace. Phosphorus vapours and gases escape through tube P.

$$\underset{\text{(calcium phosphate + silica)}}{Ca_3(PO_4)_2 + 3SiO_2} \rightarrow \underset{\text{(calcium silicate + phosphorus pentoxide)}}{3CaSiO_3 + P_2O_5}$$

$$2P_2O_5 + 10C \rightarrow 10CO + P_4$$

Properties of Phosphorus

Phosphorus condenses as a soft, pale-yellowish, wax-like solid, which melts at 44° C. It is extremely reactive and ignites in air at about 30° C. It dissolves freely in carbon disulphide and can be purified by recrystallisation from this liquid. Like oxygen (*see* Lesson 23), phosphorus exhibits the phenomenon of allotrophy ; thus if the yellow form is kept for a short time at a temperature of about 250° C. or more it gradually changes into a red amorphous solid, which is insoluble in carbon disulphide and melts at 600° C.

Red phosphorus is very much less reactive than the yellow form. Thus yellow phosphorus, when exposed to moist air in a dark room, glows with a pale green phosphorescent light and emits fumes consisting of the oxides of phosphorus. Red phosphorus, on the other hand, does not take fire in air until a temperature of about 200° C. has been reached. Red phosphorus is used in match production.

Manufacture of Matches

The first chemical matches were made in 1805 by tipping strips of wood with a mixture of sugar, potassium chlorate, and glue ; the match was ignited by dipping the tip into a small tube containing strong sulphuric acid, which reacts with potassium chlorate to produce the explosively inflammable gas chlorine dioxide. In 1827 these were superseded by the first friction matches, the tip of which consisted of a mixture of potassium chlorate and antimony sulphide. When these matches were rubbed on glasspaper, the heat of friction caused the antimony sulphide to take fire, and the combustion of the match was vigorously stimulated by the oxygen of the potassium chlorate. Because of the readiness with which it ignites, the use of yellow phosphorus soon suggested itself. The first phosphorus matches were tipped with a mixture of yellow phosphorus, some oxidising agent such as potassium chlorate, red lead, or manganese dioxide, and gum or glue ; they had this advantage—they could be struck on any rough surface ; but there were two great drawbacks to their use. Owing to their ease of ignition they were the cause of many accidental fires, and they were very poisonous. And because of the prevalence among workers in the match factories of the disease known as phossy jaw, the use of yellow phosphorus for this purpose has in most countries been prohibited by law.

Yellow phosphorus has been almost entirely replaced by the harmless red form. The match head is made from a coloured mixture of antimony sulphide, potassium chlorate or red lead, and glue ; the striking surface is coated with a mixture of red phosphorus, powdered glass, and glue, and the match will ignite only if struck on this specially prepared surface.

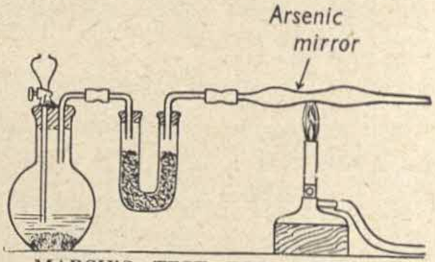
Phosphorus Compounds

Like nitrogen, phosphorus forms a hydride—phosphine, PH_3—which shows some chemical similarity to ammonia, NH_3. Thus it combines with the halogen hydrides to form what are called phosphonium salts (*cf.* ammonium salts). The reaction with hydrogen iodide is :

$$PH_3 + HI \rightarrow PH_4I.$$

Phosphorus combines directly with the halogens to form two classes of compounds—the trivalent halides, which are usually liquid, e.g. PCl_3 ; and the solid pentavalent halides, e.g. PCl_5. In general, the trivalent compounds are formed with a limited amount of halogen, the pentavalent compounds with excess of halogen. Both are vigorously hydrolysed by water according to the equations,

$$PCl_3 + 3HOH \rightarrow \underset{\text{(phosphorus acid)}}{H_3PO_3} + 3HCl$$
$$PCl_5 + 4HOH \rightarrow \underset{\text{(phosphoric acid).}}{H_3PO_4} + 5HCl.$$



MARSH'S TEST FOR ARSENIC.
Fig. 20. Arsine is prepared in the flask and deposits a shiny black mirror in the heated portion of the exit tube.

Phosphorus forms two oxides—the trioxide and the pentoxide. The trioxide, a poisonous snow-white solid, is prepared by burning phosphorus in a limited supply of oxygen. It dissolves slowly in water to form phosphorus acid according to the equation,

$$P_2O_3 + 3H_2O \rightarrow 2H_3PO_3.$$

Phosphorus pentoxide is formed when phosphorus burns in an excess of oxygen ; it is a white, odourless solid which absorbs water with great avidity, and it is therefore used as a dehydrating or drying agent. With cold water it forms metaphosphoric acid, thus :

$$P_2O_5 + H_2O \rightarrow 2HPO_3$$

but with hot water, orthophosphoric acid is formed :

$$P_2O_5 + 3H_2O \rightarrow 2H_3PO_4.$$

Orthophosphoric acid is the most important of the oxyacids of phosphorus. As each of the three hydrogen atoms is replaceable by a univalent metal, it is what is called a *tribasic* acid, giving rise to three types of salts.

Phosphorus is an important constituent of plant food. In general, it is required in the form of phosphate, but since calcium phosphate—the most commonly occurring phosphate—is practically insoluble in water, it cannot be assimilated by plants. It can, however, be converted into a soluble form by treatment with sulphuric acid ; the following reaction takes place :

$$Ca_3(PO_4)_2 + 2H_2SO_4 \rightarrow 2CaSO_4 + CaH_4(PO_4)_2$$

and the soluble acid salt, $CaH_4(PO_4)_2$, known as "superphosphate," is used as a fertilizer.

Arsenic, Antimony, and Bismuth

Arsenic, antimony, and bismuth all occur naturally in the free state and also as sulphides. They are distinctly metallic in appearance and in chemical properties, although arsenic and antimony still retain some of the non-metallic properties common to nitrogen and phosphorus. Bismuth and antimony expand on solidification, a property which has made the latter of considerable use as a constituent of type metal (lead 75 per cent.; tin 5 per cent.; antimony 20 per cent). Arsenic and antimony both form volatile hydrides—arsine, AsH_3, and stibine, SbH_3.

Marsh's test for the detection of small traces of arsenic (and antimony) depends on the formation of these hydrides. The substance suspected of containing arsenic is introduced into a flask containing zinc and sulphuric acid (Fig. 20). If arsine is present, produced by action of nascent hydrogen, a shiny black mirror is deposited in the heated tube.

Arsenic and Antimony Salts

Like phosphorus, arsenic and antimony both combine with halogens to form halides, and with oxygen to form trivalent and pentavalent oxides. These oxides show both basic and acidic properties ; in the presence of a strong acid they give salts of the type $AsCl_3$, thus :

$$\underset{\text{base}}{As_2O_3} + \underset{\text{acid}}{6HCl} \rightarrow \underset{\text{salt}}{2AsCl_3} + \underset{\text{water}}{3H_2O}$$

while in the presence of a strong base they behave as acids and give salts of the type Na_3AsO_3—sodium arsenite, thus :

$$\underset{\text{acid}}{As_2O_3} + \underset{\text{base}}{6NaOH} \rightarrow \underset{\text{salt}}{2Na_3AsO_3} + \underset{\text{water}}{3H_2O}$$

For this reason they are called amphoteric oxides.

Bismuth Salts

Bismuth exhibits weakly basic properties only, and gives salts of the type $BiCl_3$, $Bi(NO_3)_3$, etc. Because of the weakness of bismuth oxide, its salts are partially hydrolysed in water, the bismuth being almost completely precipitated in the form of a basic salt :

$$BiCl_3 + HOH \rightarrow BiOCl + 2HCl.$$

LESSON 23

Oxygen

OXYGEN is by far the most important and the most widely distributed element in nature. It occurs in the free state in the atmosphere, mixed with about four times its volume of nitrogen ; combined with hydrogen, it forms eight-ninths of the weight of water and, with many other elements, about one half of the solid matter of the earth's crust.

Since the atmosphere contains such large quantities of oxygen in the free state it is the chief source of the commercial supply of this gas. The method of separating the oxygen from the nitrogen present in the air is based on the production of liquid air. This method, the Claude process, is described in Lesson 20.

Preparation of Oxygen

Pure oxygen is readily obtained from some oxides and other oxy-compounds. Priestley and Lavoisier in their experiments obtained oxygen by heating the red oxide of mercury (Fig. 21). Peroxides also evolve oxygen ; for example, sodium peroxide, which on treatment with water decomposes to form caustic soda and oxygen, and hydrogen peroxide, which, especially in the presence of finely divided platinum, breaks down according to the equation,

$$2H_2O_2 \rightarrow 2H_2O + \overset{\nearrow}{O_2}.$$

The laboratory method of obtaining oxygen is to heat a compound rich in oxygen, such as potassium chlorate, potassium nitrate, or potassium permanganate. The reaction may be conveniently carried out in a retort as shown in Fig. 21. The oxygen, being only sparingly soluble, is collected over water.

In the case of the chlorate the equation is :

$$2KClO_3 \rightarrow 2KCl + \overset{\nearrow}{3O_2}.$$

The reaction is considerably accelerated by the addition of a small amount of manganese dioxide. Potassium chlorate alone does not decompose until a temperature of about 600° C. is reached.

Catalysis

If manganese dioxide is present, a steady stream of oxygen is evolved at about 200° C. Moreover, afterwards the manganese dioxide is found chemically unchanged.

Such a substance, which can accelerate (or retard) a reaction without itself suffering any chemical change, is called a *catalyst*, and the process is called catalysis.

Oxygen is a colourless and odourless gas, slightly heavier than air and sparingly soluble in water. Chemically it is extremely reactive and combines with most elements to form oxides.

The intense heat which is emitted when some substances burn in oxygen is made use of in the processes of welding and steel cutting. If acetylene is mixed with oxygen and burnt in the oxy-acetylene blow-pipe, the resulting flame is sufficiently hot to cut through a steel sheet.

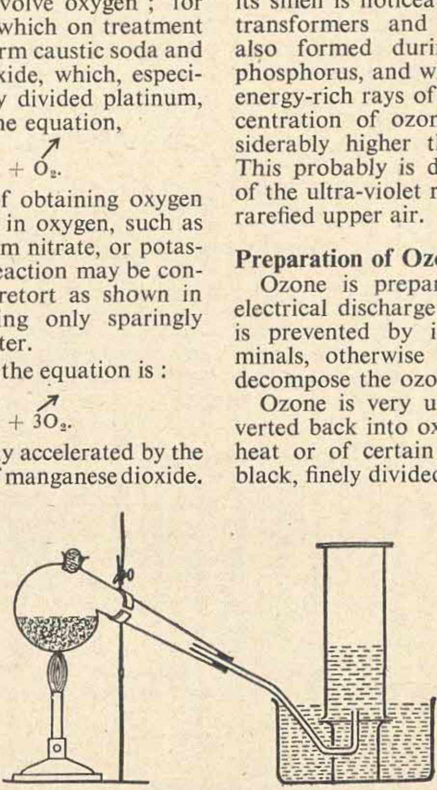
Ozone

When ordinary oxygen is subjected to the influence of an electric discharge under certain conditions, it absorbs some of the energy of the discharge and acquires a strong, garlic-like smell due to small quantities of another form of oxygen, which is called *ozone* (Gk. " smell "). Ozone is formed in various electrical processes ; its smell is noticeable in the neighbourhood of transformers and electrical machines. It is also formed during the slow oxidation of phosphorus, and when oxygen is exposed to the energy-rich rays of ultra-violet light. The concentration of ozone in the upper air is considerably higher than at the earth's surface. This probably is due to the increased activity of the ultra-violet radiation from the sun in the rarefied upper air.

Preparation of Ozone

Ozone is prepared by passing a " silent " electrical discharge through oxygen. Sparking is prevented by insulation between the terminals, otherwise the heat generated would decompose the ozone produced.

Ozone is very unstable, and is readily converted back into oxygen either by the action of heat or of certain catalysts such as platinum black, finely divided metals, manganese dioxide, and so on. Because of its unstable nature it is a very powerful oxidising agent ; it decolorises organic dyes like litmus, reacts with the metals silver and mercury, and liberates iodine from a solution of potassium iodide. It also attacks organic matter, and is used for the sterilisation of drinking water, for the purification of air in meeting-halls and in the London underground railways, and as a mild



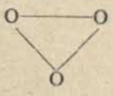
PREPARATION OF OXYGEN. Fig. 21. The gas is evolved from the retort, passes through the bent tube, and displaces water from the inverted gas-jar.

antiseptic. It dissolves readily in turpentine and oil of cinnamon.

From a consideration of the contraction in volume which oxygen undergoes on being "ozonised," it was found that three volumes of oxygen went to form two volumes of ozone. Hence from Avogadro's Law, 3 molecules of oxygen produce 2 molecules of ozone, and the reaction may be written :

$$3O_2 \rightarrow 2O_3.$$

Ozone thus contains three atoms of oxygen per molecule ; its molecular weight (48) was confirmed by density and diffusion measurements. Graphically the formula is written :



Ozone and oxygen are two distinct substances, though they are both composed of the same atoms. Such substances, which are essentially the same element but which occur in more than one form, are called *allotropic modifications*. In general, since the internal arrangements of the atoms in allotropic modifications are different, the chemical energy associated with the molecules is also different. Carbon, sulphur, phosphorus and other elements also exhibit allotropy.

Hydrogen and oxygen gases react under the influence of an electric spark to produce water—H_2O. Under some conditions they can be made to combine in another way to form a very reactive compound called hydrogen peroxide, which has the formula H_2O_2. The metallic peroxides are the usual source of this compound. Barium peroxide, when added to a well-cooled solution of dilute sulphuric acid, reacts thus:

$$BaO_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O_2.$$

The hydrogen peroxide solution is filtered off from the insoluble barium sulphate, and it is then concentrated by means of gentle distillation under reduced pressure.

Hydrogen peroxide is a colourless, syrupy liquid, which is very unstable and decomposes readily under the influence of heat or a catalyst (such as finely divided platinum, dust particles, etc.) in the following way :

$$2H_2O_2 \rightarrow 2H_2O + O_2.$$

Because of the readiness with which it yields oxygen it is a very powerful oxidising agent. Thus it liberates iodine from potassium iodide solution :

$$2KI + H_2O_2 \rightarrow 2KOH + I_2$$

and converts black lead sulphide into the white sulphate :

$$PbS + 4H_2O_2 \rightarrow PbSO_4 + 4H_2O$$

a reaction which is made use of in the cleaning of blackened oil paintings. It also oxidises organic pigments, and is used for bleaching the hair, and coloured materials such as silk, straw, feathers, etc. Dilute solutions (3 per cent.) are used as an antiseptic.

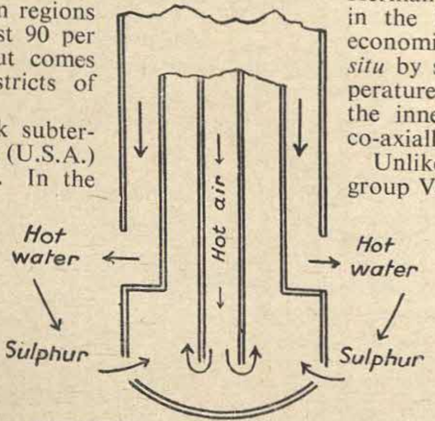
LESSON 24

Sulphur and its Compounds

The element sulphur has been known to man since the beginning of history ; it is mentioned in Homer and in the Bible as brimstone (literally firestone). It occurs in the free state in regions of volcanic activity ; almost 90 per cent. of the world's output comes from the mountainous districts of Sicily and southern Italy.

It is found also in thick subterranean deposits in Louisiana (U.S.A.) and in Japan and Iceland. In the combined state it occurs as sulphides of some metals, such as copper, iron, and zinc, and as sulphates of calcium and barium.

In the older method of extraction, carried out in southern Italy, the sulphur ore is made into a heap and fired ; the heat derived from burning a portion of the sulphur melts the rest, which runs out and is collected in wooden troughs. The modern method of extraction, invented by the German-born American chemist Herman Frasch (1852–1914) and used in the Louisiana deposits, is more economical ; the sulphur is melted *in situ* by superheated steam at a temperature of 166° C., and is forced up the inner of two steel tubes fixed co-axially, as shown in Fig. 22.



SULPHUR EXTRACTION. Fig. 22. Frasch method, in which the sulphur is melted by superheated steam.

Unlike oxygen, which it follows in group VI, sulphur is a solid at room temperatures. It is pale yellow in colour, brittle, crystalline, insoluble in water but freely soluble in carbon disulphide.

Like oxygen and phosphorus it exhibits the property of allotropism or allotropy, and exists in three well-defined modifications. Two of these—rhombic sulphur and monoclinic sulphur—are crystalline ; the third, plastic sulphur, is amorphous and unstable, passing over gradually into the stable rhombic form. Sulphur combines readily with many elements—e.g. hydrogen, oxygen, and the metals copper, iron, and tin.

Hydrogen Sulphide

Sulphuretted hydrogen or hydrogen sulphide is formed when hydrogen is passed over sulphur heated to about 400° C. or when a sulphide is acted upon by a mineral acid. In the laboratory, iron sulphide and hydrochloric acid are generally used, the reaction being carried out in a Kipp's apparatus, as shown in Fig. 14 (page 112). The equation for this reaction is written :

$$FeS + 2HCl \rightarrow FeCl_2 + H_2S.$$

Hydrogen sulphide is a colourless gas with the offensive odour characteristic of rotten eggs ; it is poisonous if breathed in quantities, and burns in air or oxygen with a blue flame similar to that of burning sulphur. Its solution in water is weakly acidic, and, since both hydrogen atoms are replaceable by a univalent metal, it may be regarded as a *dibasic* acid. Thus with caustic soda :

$$NaOH + H_2S \rightleftharpoons \underset{\text{(acid sulphide)}}{NaHS + H_2O}$$

$$2NaOH + H_2S \rightleftharpoons \underset{\text{(normal sulphide)}}{Na_2S + 2H_2O.}$$

Sulphides may therefore be considered salts of H_2S.

The sulphides of many of the heavy metals have distinctive colours, and, since their solubilities show extreme differences, they offer a convenient means of separating and identifying the metals present in a mixture of their salts. Hydrogen sulphide gas is bubbled through a solution of the metallic salts, either made acid with dilute hydrochloric acid or alkaline with ammonia. The metals are precipitated in the form of sulphides and can then be readily identified. In the case of a copper salt the equation is written :

$$CuCl_2 + H_2S \rightleftharpoons CuS + 2HCl$$

the double arrows indicating that the reverse reaction is possible if sufficient hydrochloric acid is added. It is the position of equilibrium in the above equation, or the value of the equilibrium constant,

$$K = \frac{[CuCl_2]\ [H_2S]}{[CuS]\ \ [HCl]^2}$$

which determines whether the sulphide is soluble in acid or alkaline solution.

Oxides of Sulphur

Sulphur forms two oxides—the dioxide SO_2, in which sulphur has a valency of 4, and the trioxide, SO_3, in which it is hexavalent. Sulphur dioxide is prepared by burning sulphur in air or oxygen, or by the action on a sulphite of a strong mineral acid. The equation with sodium sulphite is written :

$$Na_2SO_3 + 2HCl \rightarrow 2NaCl + SO_2 + H_2O.$$

The sulphur dioxide, being more volatile than the hydrogen chloride, escapes from the field of the reaction. Sulphur dioxide is a colourless, pungent gas, about twice as heavy as air and extremely soluble in water. Its solution has an acid reaction, and though the dibasic acid, H_2SO_3, sulphurous acid, has not been isolated, it gives rise to two well-defined series of salts. For example, with caustic soda :

$$NaOH + H_2SO_3 \rightarrow \underset{\text{(sodium bisulphite or acid sulphite)}}{NaHSO_3 + H_2O}$$

$$2NaOH + H_2SO_3 \rightarrow \underset{\text{(sodium sulphite)}}{Na_2SO_3 + 2H_2O.}$$

The acid salt is less stable than the normal salt, and on heating loses SO_2 and water thus :

$$2NaHSO_3 \rightarrow Na_2SO_3 + H_2O + SO_2.$$

Sulphur dioxide readily reduces oxidising agents such as the halogens, nitric acid, potassium permanganate, etc. The reaction with chlorine water is written thus :

$$Cl_2 + 2H_2O + SO_2 \rightarrow 2HCl + H_2SO_4\ ;$$

hence the use of SO_2 as an antichlor to remove the last traces of chlorine from articles bleached with bleaching powder. Sulphur dioxide also acts as a mild bleaching agent, and is used to decolorise straw, silk, wool, and sponge.

Sodium Thiosulphate

If sodium sulphite is heated with sulphur, a compound of considerable commercial importance—sodium thiosulphate—is formed. This was at one time known incorrectly as hyposulphite of soda, or " hypo," and it is commonly used in photography for fixing negatives. Its action is to dissolve off the sensitised plate any undecomposed silver halide left there by the developer. The reaction is written :

$$\underset{\text{(sodium thiosulphate)}}{Na_2S_2O_3} + AgCl \rightarrow NaCl + NaAgS_2O_3.$$

Like sulphites, thiosulphates are reducing agents ; with iodine, for example, this reaction takes place :

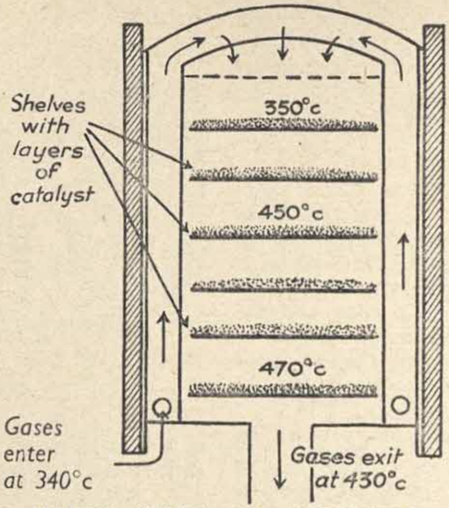
$$2Na_2S_2O_3 + I_2 \rightarrow 2NaI + \underset{\text{(sodium tetrathionate)}}{Na_2S_4O_6}$$

which forms the basis of iodimetry or titration with solutions of iodine.

Sulphur trioxide is obtained by heating the sulphates of the heavier metals, by the dehydration of sulphuric acid, or by the direct oxidation of sulphur dioxide. The velocity of the reaction,

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

increases considerably with a rise in temperature ; unfortunately, however, the reaction is attended by a large evolution of heat, so that, according to the law of Le Châtelier, an increase in temperature causes the equilibrium in the above equation to shift towards the left. With the aid of a suitable catalyst (*see* Lesson 23) it is possible to obtain a very fast reaction at a temperature of about 400° C., at which almost 98 per cent. of the gases are present as SO_3. It is upon this process that the manufacture of sulphuric acid depends.



MANUFACTURE OF SULPHURIC ACID. Fig. 23. Diagram showing the catalyst chamber in the "contact" process.

Sulphuric acid is probably the most important chemical in industry. It is used in the manufacture of phosphatic and ammonia fertilizers, dyes, explosives, hydrochloric and nitric acids, in petroleum refining, and in the electrolytic deposition and refinement of metals—to name a few of its more important uses. It is now made by one of two catalytic processes.

In the older process, the chamber process, the oxides of nitrogen—chiefly NO_2—act as the catalyst. The method consists essentially in passing sulphur dioxide—prepared by burning sulphur or heating iron pyrites (iron sulphide)—air, oxides of nitrogen, and steam into a series of leaden chambers. Here the oxidation of the SO_2 takes place, and the SO_3 which is formed combines with the steam to form sulphuric acid, H_2SO_4.

This process has been partially superseded by the contact process, in which platinised asbestos acts as the catalyst. The catalyst is prepared by heating asbestos wool which has been soaked in platinum chloride solution, leaving finely divided platinum metal dispersed evenly throughout the asbestos. Several precautions are necessary in this method; owing to the danger of "poisoning" the catalyst, care has to be taken to remove impurities, such as arsenic, which are frequently present in the sulphur dioxide obtained by burning pyrites, by passing the gases through coke filters and scrubbers. The white, mist-like SO_3 which escapes from the contact chamber is absorbed in fairly strong sulphuric acid, in which it is more soluble than water. Fig. 23 shows a diagrammatic section of a contact chamber.

The pure acid is a heavy, oily liquid—specific gravity about 1·85—which boils at 338° C. and dissolves in water with a considerable evolution of heat. It is an extremely strong acid, and, since both hydrogen atoms are replaceable by a univalent metal, it is dibasic and forms two classes of salts; thus:

$$NaOH + H_2SO_4 \rightarrow \underset{\text{(acid or bisulphate)}}{NaHSO_4} + H_2O$$

$$2NaOH + H_2SO_4 \rightarrow \underset{\text{(normal sulphate)}}{Na_2SO_4} + H_2O.$$

As it is comparatively non-volatile, it is able to displace many other acids from their salts. For example, when a chloride or nitrate is heated with strong sulphuric acid, hydrogen chloride or nitric acid is driven off, thus:

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl;$$

$$NaNO_3 + H_2SO_4 \rightarrow NaHSO_4 + HNO_3.$$

Sulphuric acid has a great affinity for water, and so is used as a dehydrating agent. Organic substances such as sugar, wood, or paper are rapidly charred by the acid; the use of sulphuric acid in the manufacture of explosives such as nitroglycerin, guncotton, etc., also depends on this property.

LESSON 25

The Chromium Group of Metals

THE elements chromium, molybdenum, tungsten, and uranium bear a certain chemical resemblance to sulphur, and are therefore included in group VIA of the periodic table. They form oxides of the type CrO_3, which, like SO_3, are acidic in character and on solution in water give rise to acids such as H_2CrO_4 (*cf.* H_2SO_4); the salts of these, acids, e.g. K_2CrO_4, are in general isomorphous with sulphates. In spite of this resemblance to sulphur, the elements have properties that are very definitely metallic; thus they all form trivalent salts of the type $Cr_2(SO_4)_3$, which in solution ionise to give positively charged metallic ions.

Of these metals, chromium is by far the most abundant; it occurs principally as chromite or chrome iron ore—$Cr_2O_3 . FeO$—in South Africa, Russia, the United States, and India. Because of its inertness towards oxygen, chromium has an extensive use in the plating of metals and the manufacture of rustless steels.

Metallic chromium, as required for rustless steels, etc., is obtained by the reduction of Cr_2O_3 by the thermite or Goldschmidt process. The oxide is mixed with powdered aluminium and a small amount of barium peroxide, and the mass ignited by means of a piece of magnesium wire. In the intense heat of oxidation of the aluminium the chromic oxide is reduced to the metal, which melts and collects at the bottom of the crucible. If the crude chromite ore is taken, the iron present forms a slag with the alumina and is removed from the surface as a scum; pure Cr_2O_3 is obtained by the hydrolysis of potassium chromite, prepared by heating the dichromate with a reducing agent.

Properties of Chromium

Chromium is an extremely hard, greyish white metal ; its melting point is 1,805° C., and it is almost completely unreactive to moist air or oxygen. It dissolves fairly readily in warm hydrochloric and sulphuric acids, forming chromous chloride and sulphate and liberating hydrogen and sulphur dioxide respectively. When chromium is added to steel, an extremely hard and tough alloy is obtained ; for this reason chrome steels are used for armour plating, high-speed tools, safes, crushing mills, stainless cutlery, etc. ; these alloys, some of which contain as much as 50 per cent. of chromium, can be prepared directly from chrome iron ores by the thermite process or by reduction with carbon in an electric furnace.

Chromium plating is carried out by making the article the cathode in a bath of a solution of chromium sulphate and chromium trioxide.

Compounds of Chromium

Chromium exhibits three valencies—2, 3, and 6—and forms three oxides, viz. chromous oxide, CrO, chromic oxide or chromium sesquioxide, Cr_2O_3, and chromium trioxide CrO_3. Chromous oxide and hydroxide are distinctly basic and form a well-defined series of comparatively stable salts, which resemble similarly constituted divalent salts, such as $CuCl_2$, $FeCl_2$, and so on. In chromic oxide the basic properties have become very much weaker ; chromic salts such as $CrCl_3$, $Cr_2(SO_4)_3$ tend to hydrolyse in water. Moreover, in the presence of a strong base the sesquioxide reacts as an acid to form chromite :

$$2KOH + Cr_2O_3 \rightleftharpoons \underset{\text{(potassium chromite)}}{K_2Cr_2O_4 + H_2O.}$$

Chromium trioxide is a strongly acidic oxide ; it may be considered to be the anhydride of chromic acid—H_2CrO_4—and reacts with bases to form chromates and dichromates.

Chromous chloride and sulphate are prepared by dissolving the metal in hydrochloric or sulphuric acid ; the chloride can also be prepared by heating anhydrous chromic chloride in a stream of hydrogen. The anhydrous salt is colourless and dissolves freely in water to form a bright blue solution. When this solution is treated with caustic soda in the absence of air, a yellowish precipitate of chromous hydroxide is formed ; this is rapidly oxidised in the presence of oxygen to the chromic state.

Chromic oxide—Cr_2O_3—is prepared by dehydrating chromic hydroxide or by heating ammonium dichromate, which decomposes according to the equation :

$$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + 4H_2O$$

the oxide is set free as a voluminous green powder, and is used in the manufacture of certain paints and pigments.

Chromic hydroxide is precipitated as a greenish-blue jelly when an alkali is added to the solution of a chromic salt. In the presence of a strong base it dissolves to form a chromite.

Chromic Salts

Chromic salts may be prepared in solution by dissolving the oxide or hydroxide in acids, or by reducing chromate or dichromate solutions with a reducing agent. These solutions may be green or violet in colour, according to the temperature and the concentration—a phenomenon which is due to the existence of different complex actions, in which the chromium is associated with molecules of water and also with the acidic element or radical, thus :

$$\underset{\text{green}}{(CrCl_2.4H_2O)^+} + 2H_2O \rightleftharpoons \underset{\text{violet}}{(Cr.6H_2O)^{+++}} + 2Cl^-.$$

Chromic sulphate is obtained in the form of violet crystals when chromic hydroxide is dissolved in hot concentrated sulphuric acid and the solution allowed to stand. With the sulphates of the alkali metals it forms a series of double salts, which are analogous to the class of compounds known as the alums (*see* Lesson 17). These salts possess a formula similar to that of the alums and are isomorphous with them, e.g. $K_2SO_4.Cr_2(SO_4)_3 . 24H_2O$; for this reason they are called the chrome alums.

Chromates and Dichromates

Chromium trioxide—CrO_3—is precipitated in the form of scarlet needles when sulphuric acid is added to a concentrated solution of a dichromate. The oxide is freely soluble in water, and gives rise to two series of salts, the chromates and the dichromates. The equations for the formation of the potassium salts are written :

$$CrO_3 + 2KOH \rightarrow \underset{\text{(chromate)}}{K_2CrO_4 + H_2O;}$$

$$2CrO_3 + 2KOH \rightarrow \underset{\text{(dichromate)}}{K_2Cr_2O_7 + H_2O.}$$

Solutions of chromates are yellow and slightly alkaline ; dichromate solutions are orange and weakly acid. Chromates are readily converted into dichromates by the addition of an acid; the addition of an alkali causes the reverse process. Both of these substances are powerful oxidising agents, dichromates being particularly strong. Thus potassium dichromate readily liberates chlorine from hot concentrated hydrochloric acid, bromine from bromides, iodine from iodides, and oxidises sulphites to sulphates, hydrogen sulphide to free sulphur, and ferrous salts to ferric salts. The powerful oxidising properties of these compounds are due to the readiness with which chromium changes its valence from 6 to 3, according to the equation

$$2CrO_3 \rightleftharpoons Cr_2O_3 + 3O.$$

Since, in acid solution, potassium dichromate contains two molecules of CrO_3, it liberates three atoms of oxygen which are available for oxidation. This may be written:

$$K_2Cr_2O_7 \rightarrow K_2O + Cr_2O_3 + 3O$$

which is the basis of the use of this salt in the titration of ferrous iron. Barium (yellow), lead (yellow), and silver (brick-red) chromates are all insoluble in water, and they are accordingly used as a means of detecting these metals in qualitative analysis.

Molybdenum is of importance in the manufacture of modern alloy steels, which are extremely hard and retain their temper under high temperature. They are used for high-speed cutting tools, rifle barrels, etc. The metal is obtained from its oxide either by the Goldschmidt process or by reduction in an electric furnace.

The most important salts of molybdenum are the molybdates, obtained by dissolving the trioxide (MoO_3) in alkalis (*cf.* chromates). Ammonium molybdate gives with a solution of a phosphate a canary-yellow precipitate of ammonium phospho-molybdate, and is used in qualitative analysis for detecting phosphates.

Tungsten occurs as scheelite ($CaWO_4$) and wolframite ($FeWO_4$); the ore is converted into the trioxide (WO_3) by roasting with sodium carbonate and treating the resultant sodium tungstate with an acid. The trioxide may then be reduced to the metal in the same manner as molybdenum. Tungsten is also used in the manufacture of tool steels, and, because of its high melting-point, in the filaments of electric lamps and thermionic valves.

Uranium, not found native, but in pitchblende, has the greatest atomic weight of all the natural elements; it forms a number of quadrivalent salts—corresponding to the oxide UO_2—and also a number of uranyl salts, produced when the amphoteric trioxide dissolves in acids.

The elements cerium and thorium are comparatively rare, but their oxides—ceria and thoria—are used in the manufacture of incandescent gas mantles and in some catalytic reactions.

LESSON 26

The Halogens

FLUORINE, chlorine, bromine, and iodine form a very important group of elements. They were called halogens (Greek, sea-salt producing) because, with the exception of fluorine, they are found in the combined state in sea water and their sodium salts closely resemble sea salt (sodium chloride).

The Table of Elements (page 91) shows that the halogens form Group VIIB in the periodic table. Owing to their extreme chemical activity, these elements occur only in the combined form in nature, usually as sodium, potassium, or calcium salts.

Chlorine

Chlorine occurs almost entirely as chlorides of sodium, potassium, and magnesium, which constitute the main part of the salts dissolved in sea water. These salts also occur in thick beds in many parts of the earth, e.g. rock salt ($NaCl$), carnallite ($KCl, MgCl_2$), sylvine (KCl), etc. Chlorine (Greek, *chloros*, green) was discovered by Karl Scheele (1742–86), in 1774, though its elementary nature was not established until 1810 by Sir Humphry Davy (1778–1829).

Chlorine is readily prepared by passing an electric current through an aqueous solution of a chloride. In the case of the sodium salt the reaction may be represented by the equation,

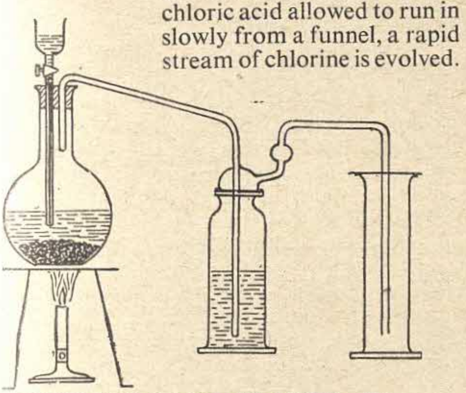
$$2NaCl \rightarrow 2Na + Cl_2$$

the sodium immediately reacts with water thus:

$$2Na + 2H_2O \rightarrow 2NaOH + H_2.$$

The net result, therefore, is that chlorine is evolved at the positive electrode (the anode), hydrogen at the negative electrode (the cathode), and sodium hydroxide accumulates in the solution. Since chlorine reacts with sodium hydroxide, precautions must be taken to prevent the chlorine from diffusing into the solution. Practically all the chlorine of commerce is obtained in this way as a by-product in the industrial manufacture of sodium and potassium hydroxides. The cells in use are described under the preparations of these hydroxides (Lesson 16).

The simplest method of preparation in the laboratory is by the action of a suitable oxidising agent on hydrochloric acid. Thus, if some compound rich in oxygen, e.g. manganese dioxide, potassium permanganate, potassium dichromate, lead dioxide, is put into a flask as shown in Fig. 24 and hydrochloric acid allowed to run in slowly from a funnel, a rapid stream of chlorine is evolved.



PREPARATION OF CHLORINE. Fig. 24. **Hydrochloric acid is run from the funnel on to manganese dioxide in the flask; the gas is bubbled through water and collected in the cylinder.**

With manganese dioxide the reaction may be written :

$$2MnO_2 + 8HCl \rightarrow 2MnCl_3 + 4H_2O + Cl_2$$

and since the manganese chloride is unstable it decomposes instantaneously according to the equation :

$$2MnCl_3 \rightarrow \underset{\text{(manganous chloride)}}{2MnCl_2 + Cl_2}.$$

Properties of Chlorine

Chlorine is a greenish-yellow gas which has a corrosive effect on the membranes of the nose, throat, and lungs. It is fairly soluble in water, but practically insoluble in strong warm brine and so can be collected over this liquid. Chemically, it is very reactive. Copper, phosphorus, and antimony ignite spontaneously in chlorine, while other elements, such as sodium and iron, burn vigorously if warmed sufficiently to start the reaction ; the compounds formed in each case are called chlorides. Chlorine also combines with hydrogen with explosive violence if the mixture is exposed to the bright light of burning magnesium wire, and it reacts vigorously with the combined hydrogen in organic compounds such as turpentine. Since it removes hydrogen from its compounds chlorine is a strong oxidising agent.

Chlorine and Iodides

Chlorine also has the property of displacing bromide and iodine from the bromides and the iodides.

Thus, if a little chlorine water is added to a solution of potassium iodide, a brown discoloration is immediately produced which gives with starch solution the deep blue of iodine. This reaction is :

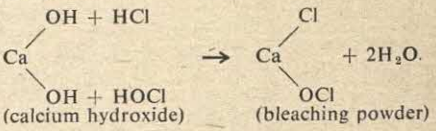
$$\underset{\text{(potassium iodide)}}{2KI + Cl_2} \rightarrow 2KCl + I_2.$$

When chlorine is passed into cold water containing a fine suspension of mercuric oxide or calcium carbonate and the resulting liquid gently distilled, a very unstable but very important substance, hypochlorous acid, is obtained. The reaction may be written :

$$Cl_2 + HOH \rightarrow HCl + \underset{\text{(hypochlorous acid)}}{HOCl}.$$

Hydrochloric and Hypochlorous Acids

The hydrochloric acid (HCl), being much the stronger acid, reacts with the mercuric oxide or calcium carbonate so that the solution becomes increasingly stronger in hypochlorous acid. If a cold solution of sodium hydroxide is used instead of water, a mixture of sodium chloride and hypochlorite is formed ; if calcium hydroxide is used, calcium hypochlorite, or bleaching powder, is obtained. The reaction is generally written :



$$\underset{\text{(calcium hydroxide)}}{Ca\begin{matrix}OH + HCl\\ OH + HOCl\end{matrix}} \rightarrow \underset{\text{(bleaching powder)}}{Ca\begin{matrix}Cl\\ OCl\end{matrix}} + 2H_2O.$$

Bleaching Powder

Bleaching powder is the most important salt of hypochlorous acid. It is manufactured on a large scale by the action of chlorine on moist slaked lime, spread out on shelves in leaden chambers. The bleaching powder which is obtained in this way contains about 33–38 per cent. of chlorine. On treatment with dilute acid, hypochlorous acid is immediately set free, and this reaction takes place :

$$HCl + HOCl \rightarrow H_2O + Cl_2.$$

Bleaching powder contains a large amount of more or less free chlorine. It is this so-called free chlorine which gives bleaching powder its bleaching properties. The process of bleaching depends on the oxidation of the coloured compounds used for dyeing cloths. These oxidation products are colourless, and, since chlorine is a strong oxidising agent, it has the property of being able to decolorise the cloth.

Hypochlorite and Chlorates

If chlorine is passed into a hot solution of potassium hydroxide, the hypochlorite is converted into chlorate in this way :

$$3Cl_2 + 6KOH \rightarrow \underset{\text{(potassium hypochlorite)}}{3KClO} + 3KCl + 3H_2O.$$

$$3KClO \rightarrow \underset{\text{(potassium chlorate)}}{KClO_3} + 2KCl.$$

On cooling, the chlorate crystallises out. Potassium chlorate is a powerful oxidising agent ; it gives off oxygen if heated. It is used medicinally ; in the manufacture of matches, fireworks, and explosives ; and for preparing small amounts of oxygen.

When sodium or potassium chloride is heated with strong sulphuric acid, a colourless, fuming gas with an irritating, acrid smell is given off. This is hydrogen chloride, and the reaction is represented by the equation,

$$\mathrm{NaCl + H_2SO_4 \rightarrow \underset{(sodium\ bisulphate)}{NaHSO_4} + HCl.}$$

Properties of Hydrochloric Acid

The gas is extremely soluble in water and must therefore be collected by an upward displacement of air. When prepared commercially, the gas is passed up towers down which water trickles ; and the solution of hydrochloric acid, often called muriatic acid, is used in the dye industry, chlorine bleaching industry, and so on. Hydrochloric acid is an extremely strong acid ; it dissolves certain metals, e.g. zinc and iron, forming the chloride of the metal and giving a rapid evolution of hydrogen gas. It also reacts with oxides, hydroxides, or carbonates of the metals to give the chlorides and water, e.g.

$$\mathrm{Ca(OH)_2 + 2HCl \rightarrow \underset{(calcium\ chloride)}{CaCl_2} + 2H_2O.}$$

Like chlorine, bromine and iodine are very reactive chemically, and so do not occur in the free state in nature. Bromine is found in combination with sodium, potassium, magnesium, and calcium in sea water and in the waters of certain salt springs. Iodine occurs in small quantities as sodium and potassium iodides in seaweed or kelp, and as sodium iodate, which is present in sodium nitrate deposits in Chile.

Preparation of Bromine

Bromine was discovered by Antoine Balard (1802–76) in 1826 ; he noticed that when chlorine water was added to the mother liquor which remained after the crystallisation of salt from certain spring waters, a deep brown coloration was produced. Balard established the elementary nature of this substance, which he called bromine (Gr. *bromos*, stench), and showed its chemical relation to chlorine and iodine. The modern commercial method of extraction of bromine is similar in principle to that used by Balard.

In the laboratory, bromine is prepared in a similar manner to chlorine, by heating a mixture of potassium or sodium bromide, manganese dioxide, and strong sulphuric acid. The reaction is written thus :

$$\mathrm{MnO_2 + 2KBr + 2H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + Br_2 + 2H_2O.}$$

Iodine was first prepared by Bernard Courtois (1777–1838) in 1812. The ash obtained by burning seaweed or kelp was extracted with water, and the liquid, after crystallisation to remove the alkali carbonates, sulphates, and chlorides, was either treated with chlorine or it was heated with manganese dioxide and sulphuric acid.

Preparation of Iodine

The evolved iodine was purified by sublimation in iron retorts. Though this method is still used to some extent, the main part of the world's supply of iodine is now obtained from the liquid left after the crystallisation of sodium nitrate from Chile saltpetre or caliche. This liquid contains a large amount of sodium iodate, a highly oxidised form of iodine, similar in nature to sodium chlorate, and the iodine is recovered from this compound by the aid of a reducing agent. The substance used for this purpose is sodium bisulphite, a salt of the acidic oxide, sulphur dioxide. The reaction is represented by the equation,

$$\mathrm{\underset{(sod.\ iodate)}{2NaIO_3} + \underset{(sod.\ bisulphite)}{5NaHSO_3} \rightarrow 3NaHSO_4 + 2Na_2SO_4 + H_2O + I_2.}$$

The iodine is pressed into blocks and purified by sublimation.

Properties of Bromine and Iodine

Bromine is a heavy, reddish-brown, fuming liquid a little more than three times as heavy as water. It is very poisonous, has a disagreeable smell, and attacks the skin and the membranes of the nose and throat. It is fairly soluble in water, giving bromine water. Iodine is a dark-blue, crystalline solid which on heating becomes a violet vapour. It is only sparingly soluble in water, but it dissolves readily in a weak aqueous solution of potassium iodide, and also in organic solvents such as chloroform, ether, and alcohol.

Their Chemical Reactions

In their chemical reactions bromine and iodine show a strong resemblance to chlorine, but they are both rather less vigorous. There is, in fact, a definite gradation of both physical and chemical properties in passing from chlorine to iodine, and this corresponds to the change in atomic weight—chlorine 35·5 (gas) ; bromine 79·9 (liquid) ; iodine 126·9 (solid)—and therefore to the position of these elements in the periodic table. For example, iodine shows the least tendency to combine with hydrogen, hydrogen iodide being usually prepared by indirect means and not by direct combination, as in the case of hydrogen chloride and hydrogen bromide. Bromine and iodine combine spontaneously with some elements, e.g. phosphorus, antimony, copper, iron, to form bromides and iodides, which are similar in character to the corresponding chlorides. Like chlorine, both of these elements are oxidising agents, and for this reason they have mild bleaching properties. Since chlorine is able to displace bromine and iodine from bromides and iodides, and since bromine is able to displace iodine in the same way, this is equivalent to saying that, of the three, chlorine is the strongest oxidising agent and iodine the weakest.

When in contact with starch, iodine forms an intense blue coloration, a reaction which is so delicate that it reveals the presence of 0·0000001 gram of iodine. The use of iodine in medicine is well known. Iodine is also used in photographic processes, together with bromine, and in the dye industry.

Hydrogen Bromide and Hydrogen Iodide

Both hydrogen bromide and hydrogen iodide resemble hydrogen chloride, and the methods of preparation are similar, though, owing to the fact that these compounds are much less stable than the chloride, minor differences occur. They cannot be prepared, for example, by the action of strong sulphuric acid on a bromide or iodide, as they are both strong reducing agents and immediately react with sulphuric acid ; the equation for the bromide is written :

$$2HBr + H_2SO_4 \rightarrow \underset{\text{(sulphur dioxide)}}{SO_2} + 2H_2O + Br_2.$$

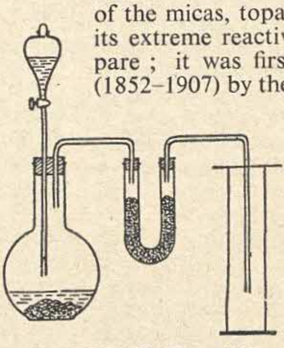
It is, however, possible to select a non-volatile acid, such as phosphoric acid, with which they do not react, and the reaction is similar to the preparation of hydrogen chloride. It is written in the case of the bromide :

$$3NaBr + \underset{\text{(phosphoric acid)}}{H_3PO_4} \rightarrow \underset{\text{(sodium phosphate)}}{Na_3PO_4} + 3HBr.$$

A simpler method of preparation is to treat the halide of a non-metallic element, such as phosphorus, with water. An energetic reaction takes place in accordance with the equation :

$$\underset{\text{(phosphorous tribromide)}}{PBr_3} + 3H_2O \rightarrow \underset{\text{(phosphorous acid)}}{P(OH)_3} + 3HBr.$$

In practice the phosphorous trihalide is prepared in the course of the experiment. In the case of the bromide, bromine is slowly added from a dropping funnel to a mixture of red phosphorus, sand, and water contained in a flask as shown in Fig. 25. The gas is passed through a U-tube containing red phosphorus, which removes any free bromine that may have been carried over.



PREPARATION OF HYDROGEN BROMIDE. Fig. 25. Bromine runs on to a mixture of red phosphorus, sand, and water; the gas is then passed through a U-tube which contains red phosphorus, and collected in the cylinder (on right).

Like hydrogen chloride, these substances are pungent, colourless gases which fume strongly in air, produce dense white clouds with ammonia gas, and are extremely soluble in water. The aqueous solutions, which are called hydrobromic and hydriodic acids, have all the properties of a strong acid ; with some metals, e.g. zinc, they liberate hydrogen, and they react with bases to give halides of the same general type as sodium chloride.

Properties of these Halogen Compounds

Hydrogen bromide and iodide are much more easily decomposed than hydrogen chloride, and since on decomposition they liberate hydrogen and are thus able to remove oxygen from its compounds, they are very strong reducing agents. In general, these halogen compounds with hydrogen show a similar gradation of chemical properties to the halogens themselves. Thus hydrogen chloride is stable towards heat ; the bromide is decomposed at 800° C., the iodide at about 450° C. Similarly, the vigour of their reactions with oxidising agents shows a steady change.

To obtain chlorine from hydrogen chloride, it is necessary to use a strong oxidising agent such as manganese dioxide ; hydrogen iodide, or its aqueous solution, on the other hand, is decomposed by the oxygen of the air, thus :

$$4HI + O_2 \rightarrow 2H_2O + 2I_2.$$

Fluorine and Hydrogen Fluoride

Fluorine is found in the form of fluorides such as fluorspar (CaF_2), cryolite, a double fluoride of sodium and aluminium, and in some of the micas, topaz, and tourmaline. Owing to its extreme reactivity it is very difficult to prepare ; it was first isolated by Henri Moissan (1852–1907) by the electrolysis in a copper vessel of a well-cooled solution of potassium fluoride in hydrogen fluoride. Chemically speaking, fluorine is the most active element known, and it combines with practically every other element. It displaces chlorine from chlorides, and for its oxidising power it therefore stands at the head of the halogen family.

Hydrogen fluoride resembles the other halogen compounds with hydrogen, and is prepared by the action of sulphuric acid on powdered fluorspar in leaden vessels. The gas is collected in water and stored in lead, rubber, or wax bottles. Its chief use is in the process of glass etching. Hydrogen fluoride reacts with the silica of glass according to the equation,

$$\underset{\text{(silica)}}{SiO_2} + 4HF \rightarrow \underset{\text{(silicon tetrafluoride)}}{SiF_4 + 2H_2O}$$

The surface of the glass is covered with wax, the design is scratched in the wax, and the surface is then exposed to the action of hydrofluoric acid.

LESSON 27

Manganese, Iron, and Associated Metals

THE metal manganese occurs in group VIIA of the periodic table and might therefore be expected to show a chemical resemblance to the halogens, chlorine, bromine, and iodine, which are members of group VIIB. Actually this similarity exists only between compounds of the typical group oxide—Mn_2O_7; thus manganese heptoxide—the anhydride of permanganic acid ($HMnO_4$)—gives rise to a series of salts called permanganates, which are isomorphous with perchlorates (salts of Cl_2O_7 and $HClO_4$). In its lower stages of oxidation, manganese resembles the metals of corresponding valence; for example, manganous sulphate ($MnSO_4$) reacts chemically in a similar manner to zinc sulphate and nickel sulphate.

Manganese in Metallurgy

Manganese occurs fairly widely distributed, usually in the form of pyrolusite (MnO_2). As its use in industry depends chiefly on the production of an alloy with iron, the crude manganese ore is mixed with iron ores and reduced in a blast furnace in the ordinary way. The pure metal can be prepared by the Goldschmidt process. Manganese when alloyed with steel forms a hard manganese steel which is very tough and strong and, unlike unalloyed steel, it does not become hard and brittle when heated and quenched. For this reason it is used for bends and junctions of tram and train rails, which are subject to excessively hard wear. It is also used for making safes and crushing machinery, and for steel helmets.

Oxides and Compounds of Manganese

Manganese forms seven oxides, of which the most important are manganous oxide (MnO) and manganese dioxide (MnO_2). Manganous oxide, prepared in the form of a greyish-green powder by heating the hydroxide or carbonate, is basic in character and reacts with acids to form stable manganous salts. These are pink in colour and, when treated with a solution of a caustic alkali, give a colourless precipitate of manganous hydroxide, which rapidly darkens in the presence of oxygen owing to the formation of the higher oxides. Manganese dioxide—dark brown or black in colour—is obtained when a manganous salt is oxidised or when a permanganate is reduced in alkaline solution with hydrogen peroxide or a manganous salt (a method which is used as a means of estimating manganese). The dioxide is practically insoluble in water, but with strong acids it reacts as a weak base to form unstable quadrivalent salts, which recompose on warming to give a manganous salt and either oxygen or an oxidation product of the acid used (*cf.* preparation of chlorine). Manganese dioxide acts as a catalyst in many reactions in which oxygen is produced, e.g. in the decomposition of potassium chlorate and also of hydrogen peroxide.

With strong bases, manganese dioxide reacts as a weak acid; when fused with potassium hydroxide or carbonate in the presence of air or of an oxidising agent such as potassium nitrate, it forms a dark green mass of potassium manganate, thus:

$$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O.$$

Manganates, which are salts of the unstable acidic oxide (MnO_3), are stable in the presence of an alkali, but in neutral or acid solution they tend to hydrolyse, forming a black deposit of MnO and a purple solution of permanganate, thus:

$$3K_2MnO_4 + 2H_2O \rightarrow 2KMnO_4 + MnO_2 + 4KOH.$$

Permanganates—salts of the strongly acidic oxide, Mn_2O_7—are prepared by adding dilute sulphuric acid to the manganate:

$$3K_2MnO_4 + 2H_2SO_4 \rightarrow 2K_2SO_4 + 2KMnO_4 + MnO_2 + 2H_2O.$$

Permanganates

Potassium permanganate, which crystallises in the form of dark purple crystals, is a powerful oxidising agent, and when heated alone it decomposes freely at temperatures above 240° C., giving oxygen and MnO_2. In solution it is used in volumetric analysis for the estimation of solutions containing reducing agents such as sulphurous acid, sulphites, ferrous salts, oxalic acid, and oxalates. Owing to its intense purple colour and also to the fact that in these reactions it is reduced to colourless manganous salts, no indicator is required in permanganate titrations. As a rule the permanganate is titrated into an acid solution (containing sulphuric acid) of the reducing substance; the basis of the reaction is:

$$Mn_2O_7 \rightarrow 2MnO + 5O$$

that is, 2 molecules of $KMnO_4$ liberate 5 atoms of oxygen for oxidation purposes. In alkaline solution the reaction follows another course, manganese dioxide is precipitated as follows:

$$Mn_2O \rightarrow 2MnO_2 + 3O$$

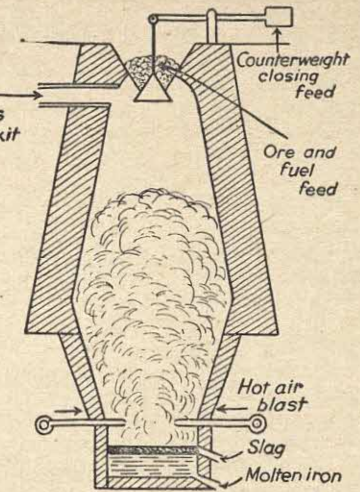
two molecules of permanganate in this case liberate 3 atoms of oxygen. Potassium permanganate is also much used for bleaching and for its antiseptic properties.

Iron is by far the most important metal of modern times. With the sole exception of aluminium, iron is also the most abundant metal, and because it can be obtained cheaply and with greater ease than aluminium, has many uses.

Iron

Iron is also found in the body as an essential constituent of the haemoglobin contained in the red corpuscles, and is present in many of the body proteins and in such foods as shell-fish, eggs, fruit, and meat, particularly liver.

Iron occurs chiefly as oxide, carbonate, and sulphide. The more important oxide ores are magnetite, Fe_3O_4; haematite, Fe_2O_3; and limonite, a hydrated Fe_2O_3. The sulphide, FeS_2, is abundant, but owing to the difficulty in removing the sulphur it has little value.



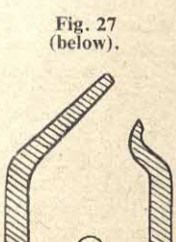
BLAST FURNACE. Fig. 26. Ore, mixed with coke and limestone, is fed in at the top, and molten metal and slag drawn off at the bottom. The high temperature necessary is maintained by means of a hot air blast.

The first stage in the extraction of the metal is to mix the ore with coke and limestone and roast it strongly in a blast furnace, as shown in Fig. 26. This is a fire-brick tower, generally about 100 ft. in height and 25 ft. across at its widest part; the ore is fed in at the top, and the hot air required for the combustion is led in near the bottom through pipes called *tuyeres*. The essential reactions in the furnace are first the formation of carbon monoxide from the coke and air-blast at the bottom, and then the reduction of the ore according to the equation

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2.$$

The large amount of heat evolved in the formation of the carbon monoxide is sufficient to melt the iron, which collects at the base of the furnace and is run off at intervals into moulds.

Fig. 27 (below).



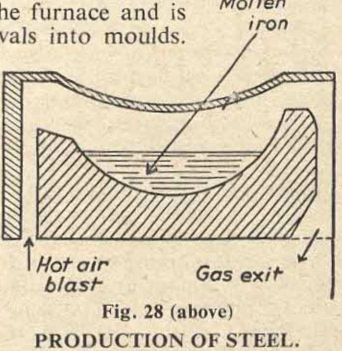


Fig. 28 (above)

PRODUCTION OF STEEL. Fig. 27. Bessemer converter, for the conversion of pig iron into steel; impurities are burnt off by a blast blown through the molten metal. Fig. 28. Siemens open-hearth steel furnace.

Iron produced in this way is called pig or cast iron. The lime of the limestone combines with impurities such as silica, alumina (clay), and phosphorus to form a liquid slag, and this slag collects on the surface of the molten metal. Cast iron contains about 3 to 4 per cent. of carbon, and is too brittle to be worked easily.

Steel is made by the Bessemer process, in which the molten iron from the blast furnace is run straight into a pear-shaped iron vessel called a *converter* (Fig. 27) and the carbon and other impurities are burnt off in the form of oxides by a blast of air blown through the liquid metal. When the impurities are removed, a definite amount of cast iron containing carbon and manganese is added to produce steel of the required composition. The converter is often lined with bricks made of lime and magnesium carbonate, and the phosphorus which the iron contains is converted into phosphates in the form of a slag, which is sold as fertilizer under the name *basic slag*. Cast iron is sometimes converted into steel by the Siemens open-hearth process (Fig. 28), slower than the Bessemer but giving a more uniform product.

Steel contains amounts of carbon varying from 0·2 (mild steel) to 1·5 (hard tool steel) per cent.; medium steel, used in structural work, contains about 0·5 per cent. The quality of steel is also considerably affected by the process of tempering; the steel is heated to temperatures up to about 300° C. and cooled very gently. In general, the higher the temperature the softer is the resulting metal. When steel is heated to redness and cooled suddenly by being plunged into cold water, it becomes so hard that it will scratch glass. The addition of chromium (for rustless steels), manganese (ferro-manganese), and nickel (nickel steels) is dealt with in the sections on these metals.

Oxides of Iron

Iron dissolves readily in dilute hydrochloric and sulphuric acids, liberating hydrogen and forming the ferrous salt. Concentrated nitric acid renders the metal unreactive, or, as it is called, passive, presumably owing to the formation of a film of oxide, which can be removed by scratching or by the action of a reducing agent. Iron is not attacked by pure water, but in the presence of moist air containing carbon dioxide it is rapidly corroded with the formation of a loosely attached porous mass of hydrated oxide —$Fe_2O_3H_2O$—which is iron rust. If the air and water are completely freed from carbon dioxide no rusting takes place ; the mechanism of the process is by no means clear, but it seems probable that it is due first to the formation of an acid carbonate, which subsequently decomposes to form the hydrated oxide.

Iron forms three oxides : ferrous (FeO), ferric (Fe_2O_3), and ferroso-ferric (Fe_3O_4), also called magnetic iron oxide or magnetite. Ferrous oxide is fairly strongly basic and gives rise to a well-defined series of salts of which ferrous sulphate is perhaps the most important. It is obtained as light green crystals, sometimes called green vitriol, having the formula $FeSO_4 . 7H_2O$, when iron is dissolved in dilute sulphuric acid and the resulting solution evaporated. Ferrous sulphate is used as a mordant in the dye industry, and in the manufacture of inks ; when added to the extract of nut galls, which contains tannic acid, it is converted into ferrous tannate. This substance is soluble in water and colourless, but on exposure to air it is oxidised to ferric tannate, which is insoluble in water and forms a fine black precipitate. Gum arabic is usually added to the ink to make it adhesive, and a little blue-black dye to make the writing visible before oxidation.

Ferric Salts

On exposure to air or on treatment with an oxidising agent, ferrous salts are converted into ferric salts. Ferric oxide—Fe_2O_3— occurs naturally as haematite, limonite, and specular iron ore, and hydrated as rust. It is formed by roasting ferrous sulphate or ferric hydroxide in air. As is to be expected from the increased oxygen content, it is a much weaker base than ferrous oxide, and ferric salts are appreciably hydrolysed in water. Thus, in the case of the chloride, this reaction takes place :

$$FeCl_3 + 3HOH \rightleftharpoons Fe(OH)_3 + 3HCl$$

and can readily be shown by the process of dialysis. The hydrochloric acid passes through the parchment paper, leaving a colloidal solution of ferric hydroxide. When an alkali is added to the solution of a ferric salt, a flocculent reddish-brown precipitate of ferric hydroxide is formed.

Ferroso-ferric oxide is formed when iron is heated to redness in the presence of air or steam ; the reaction in the latter case is written

$$3Fe + 4H_2O \rightleftharpoons Fe_3O_4 - 4H_2$$

This oxide has magnetic properties—hence its name, magnetite—and reacts chemically as if it were a mixed oxide, having the formula $FeO.Fe_2O_3$.

When potassium cyanide solution is added to the solution of a ferrous salt, ferrous cyanide is at first precipitated, but this gradually dissolves in excess of the potassium salt, to give finally a solution of potassium ferrocyanide ; the equation is :

$$Fe(CN)_2 + 4KCN = K_4Fe(CN)_6.$$

Potassium ferrocyanide is a yellow, crystalline solid, which, unlike potassium cyanide, is non-poisonous. With a solution of a ferric salt, it gives an intense dark blue precipitate, which is called Prussian blue and has the formula $Fe_4(Fe(CN)_6)_3$.

If potassium cyanide is added in excess to the solution of a ferric salt, potassium ferricyanide is formed. This salt, which crystallises as red prisms, has the formula $K_3Fe(CN)_6$; when added to a solution of a ferrous salt, potassium ferricyanide gives a dark blue precipitate, which is another form of Prussian blue. These two reactions are used as distinguishing tests for ferrous and ferric iron in solution. A solution of a ferric salt also reacts with a thiocyanate to produce a vivid red colour, which is used in detecting ferric iron.

Cobalt and Nickel

Cobalt and nickel are associated with iron in group VIII of the periodic table. The elements of this group occur in groups of three, which have comparable atomic weights, e.g. Fe (55·84), Co (58·94), Ni (58·69). Cobalt and nickel occur together in nature, usually in the form of sulphide or arsenide. Cobalt ores are first converted to oxide by roasting in air and then reduced to metal by the Goldschmidt process or by heating with carbon. Nickel ores, which usually contain iron and copper, are roasted in a blast or reverberatory furnace to remove arsenic, and then transferred to a converter similar to that used in the Bessemer steel process. Most of the iron, present as impurity, is converted into slag, and the resulting mixture of nickel and copper sulphides is roasted to oxide and refined either by fusion with coal and sodium sulphate or by the Mond carbonyl process (*see* Lesson 18).

Both metals are silver-white in appearance and resemble iron in density, melting point, and magnetic properties. They are, however, much more resistant to corrosion, and are used in non-corrodible alloys and in plating copper and iron vessels.

Nickel-Steel Alloys

The addition of nickel to steel gives alloys of great strength and varying degrees of elasticity. Steel containing 35 per cent. of nickel, a little carbon, and manganese, is called " Invar," and it does not show any appreciable expansion or change in elasticity when heated. Platinite, a steel alloy containing about 45 per cent. of nickel, has almost the same thermal coefficient of expansion as glass, and it is used for sealing leads into electric light bulbs and radio valves. Nickel is also alloyed with chromium and with copper in the production of monel metal (Ni 60 per cent., Cu 35 per cent., Fe 5 per cent.) and of German silver (Ni 25 per cent., Cu 55 per cent., Zn 20 per cent.). The use of finely divided nickel as a catalyst has been mentioned.

These metals form several series of compounds, of which the divalent ones, corresponding to the oxides, CoO (cobaltous) and NiO (nickelous), are the most important. Both oxides are formed by the action of heat on the hydroxide or carbonate, and dissolve in mineral acids to form the appropriate salt. Cobalt salts are generally pink, an exception being cobalt hydroxide, $Co(OH)_2$, which is formed as a blue precipitate when a caustic alkali is added to a cobaltous solution. On boiling, the hydroxide becomes pink, presumably owing to a change in the degree of hydration. Nickel salts are generally green, and on treatment in solution with a caustic alkali give an apple-green precipitate of nickelous hydroxide.

When sulphuretted hydrogen is passed into a solution of a cobalt or a nickel salt which has been made alkaline with ammonia, finely divided black precipitates of the sulphides are formed. These sulphides are insoluble in dilute acids, though, curiously, they are not precipitated if the solutions are first made slightly acid. The most probable explanation is that there are two modifications of the sulphides.

Two other triads of elements (*cf.* Fe, Ni, and Co) occur in group VIII of the periodic table, namely ruthenium, rhodium, and palladium, and osmium, iridium, and platinum. All of these metals are comparatively rare, and because they are unreactive and occur in the free state in nature they belong to the class called the " noble " metals. Palladium, iridium, and platinum are the most important.

The Platinum Metals

Palladium differs from the other two in that it dissolves fairly readily in nitric and strong sulphuric acids. All three metals dissolve in aqua regia (3 parts of HCl to 1 of HNO_3), and if this solution is gently heated with hydrochloric acid until all the nitric acid is expelled, the quadrivalent chloride of the metal is obtained. These chlorides are comparatively unstable, but if recrystallised from a solution containing ammonium chloride they form a stable complex salt of the type $(NH_4)_2PtCl_6$, ammonium chloroplatinate, which is the salt of chloroplatinic acid (H_2PtCl_6). When heated, this salt decomposes, giving first platinum chloride and ammonium chloride, and finally, with stronger heating, finely divided platinum. Platinum, especially when in a fine state of subdivision, is a powerful catalyst ; the activity of colloidal platinum and the use of platinised asbestos in the catalytic preparation of sulphuric acid have been mentioned. In the latter case the catalyst is prepared by heating asbestos which has been soaked in a solution of chloroplatinic acid. Because of its rarity and resistance to corrosion, platinum is selected as a setting for jewelry. Its thermal coefficient of expansion is almost exactly the same as that of glass, and it is used for sealing metal leads into electric light bulbs.

LESSON 28

Chemistry of the Organic Compounds

It is mentioned in Lesson 18 that the old distinction between organic and inorganic chemistry had its origin in the belief that many of the carbon compounds found associated with living things could be produced only by the agency of vital organisms ; these animal and vegetable products were therefore known as organic compounds, and for a long time it was thought impossible to prepare them artificially in the laboratory. This distinction existed until 1828, when the German chemist Friedrich Wöhler (1800–82), succeeded in preparing urea (an excretion of animal organisms) by synthesis from an inorganic salt called ammonium thiocyanate.

This discovery was soon followed by others of a similar kind, chiefly at the hands of the French chemist Marcelin Berthelot (1827–1907), who is sometimes referred to as the founder of synthetic chemistry. In about the middle of the 19th century Berthelot prepared synthetic acetylene by the direct combination of carbon and hydrogen, and then made alcohol, formic acid, fats, and sugars, as well as derivatives of each of these compounds. Not only can many vital products now be made artificially, but the synthetic chemist can prepare a constantly increasing host of bodies, as, for example, valuable drugs, which are closely allied to vital products but which are entirely unknown in nature. The name " organic chemistry " is now therefore more or less loosely applied to the chemistry of the carbon compounds.

Composition of Organic Compounds

Compounds containing carbon occur in extraordinary abundance—more than three million are known. In spite of their great number they are closely related to one another, and show general properties which are quite different from those compounds containing other elements. Many of these compounds are made up of two elements only—carbon and hydrogen—and are called hydrocarbons ; some, such as the carbohydrates, sugar, starch, etc., contain oxygen also ; others contain nitrogen as well as the other three elements ; others, again, contain sulphur, phosphorus, the halogens, and other elements.

Because of the chemical resemblances which exist between organic compounds, their separation from a mixture, purification, and analysis differ considerably from the methods used in the case of inorganic compounds. Separation from a mixture or from an inorganic substance may be effected either by dissolving the constituent compounds in a suitable solvent, such as alcohol, ether, chloroform, or benzene, which does not generally dissolve inorganic salts, or by the process of fractional distillation. In the first case a separating funnel is used (Fig. 29) with solvents which do not mix, and the solutions divide in layers, and can be run out separately ; the second process, applicable to mixtures of liquids, depends on the fact that many mixtures containing two liquids of different boiling points boil at some intermediate temperature, the value of which depends on the amount of each substance present. The method is simply to distil the mixture and collect the distillate in fractions at intervals of 5° or 10°. Each of these portions is then refractionated, and in this way it is possible to separate the components in what is a practically pure condition, boiling at constant temperatures.

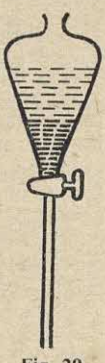


Fig. 29

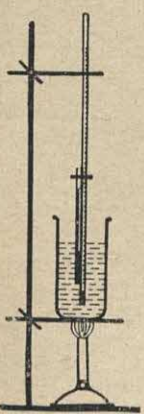


Fig. 30

Tests of the purity of organic compounds are usually made by observing the melting point (in the case of a solid) or the boiling point (in the case of a liquid). Pure substances have very definite melting and boiling points, and the presence of impurities not only makes the values indefinite but also lowers the melting point and often raises the boiling point. Melting point determinations are carried out in the apparatus shown in Fig. 30. A minute amount of the substance is placed in a capillary tube sealed at the bottom and attached to a thermometer. It is then immersed in a small beaker containing some high boiling liquid, e.g. liquid paraffin, which is vigorously stirred during the heating. The paraffin is heated very gently and the temperature at which the substance just melts is observed.

Determination of the melting point can also help to identify an unknown organic compound.

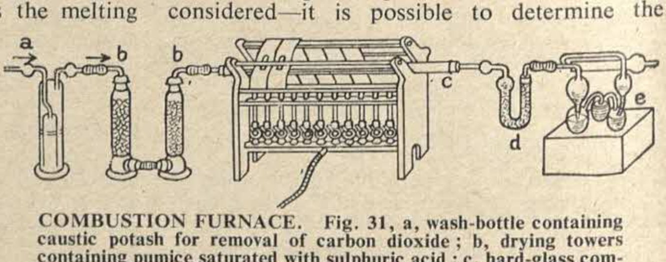
Quantitative Analysis

Tests for purity are supplemented by an estimation of the quantities in which the various elements are present in the compound. Practically all organic compounds, when passed through red-hot copper oxide, are completely decomposed, the carbon being oxidised to carbon dioxide and the hydrogen to water. The method of estimating carbon and hydrogen, therefore, consists in oxidising a known weight of the substance and collecting and weighing the products, which are carried through the furnace by a stream of pure, dry air or nitrogen. A furnace is shown (diagrammatically) in Fig. 31; water is absorbed in weighed calcium chloride tubes and carbon dioxide in potash bulbs.

If nitrogen is present, it is estimated by the method of Jean Dumas (1800–84) or of Kjeldahl (1849–1900). In the former the nitrogenous substance is ignited with copper oxide as before. The combined nitrogen is set free as nitrogen gas, and after absorption of the carbon dioxide in potash its volume is measured in a graduated tube called a *nitrometer*. Kjeldahl's method depends on the fact that when compounds containing nitrogen are completely decomposed by hot concentrated sulphuric acid, the nitrogen is converted into ammonium sulphate. Estimation of the ammonia present gives the amount of nitrogen.

Chlorine, bromine, and iodine are generally estimated by the method of George Carius (1829–75), in which the compound is oxidised by means of concentrated nitric acid in the presence of silver nitrate. The decomposition is carried out in a sealed strong glass tube, about 40 cm. long, heated to about 180° C. for some hours. When quite cold, the silver halide is removed, and the halogen present estimated.

Other elements, such as the metals, may be estimated by the methods used in inorganic determinations. From the quantitative estimation of the various elements present—that is, the percentage composition of the substance considered—it is possible to determine the

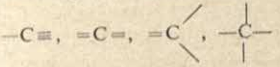


COMBUSTION FURNACE. Fig. 31, a, wash-bottle containing caustic potash for removal of carbon dioxide ; b, drying towers containing pumice saturated with sulphuric acid ; c, hard-glass combustion tube ; d, weighed tube containing calcium chloride to collect water ; e, weighed potash bulbs to absorb carbon dioxide.

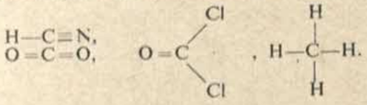
simplest expression of the ratio of the atoms in a molecule ; this is termed the empirical formula of the compound. Its true molecular formula is then obtained by reference to its molecular weight, which is determined by one of the methods described in Lessons 2 and 8, if the substance is a liquid, by measurement of the vapour density ; if a solid, by measurement of the lowering of freezing point or elevation of boiling point of a solvent.

After the molecular formula of an organic compound has been established there still remains the difficult task of determining the arrangement of the atoms within the molecule, i.e. the graphic or structural formula of the compound. Many cases exist where two or more entirely different organic compounds have the same molecular formula, as, for example, methyl formate and acetic acid ($C_2H_4O_2$), referred to in Lesson 5. Similarly, there are two compounds having the formula C_4H_{10}, three of the formula C_4H_{12}, at least six of the formula $C_3H_6O_2$, and so on. It is essential, therefore, that the arrangements of the atoms within the molecule should be determined, and this can be done indirectly from a consideration of the valencies of the elements in the compound, and also its chemical and physical properties.

No compound is known containing one atom of carbon combined with more or less than four univalent elements or their valency equivalent ; carbon, therefore, is always quadrivalent (*see* Lesson 18), and the arrangements of its four valency bonds may be written graphically thus :



according as to whether it is attached to trivalent, divalent, or univalent atoms. This may be illustrated by such compounds as

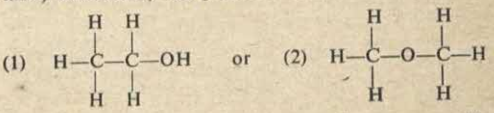


Each of these forms of linkage reacts chemically in a particular manner, so that from a consideration of the chemical reactions of the substance it is possible to decide on the nature of the linkage. Similarly,

divalent oxygen may be $= O$ or $— O —$,
trivalent nitrogen $\equiv N$ or $> N—$,
and so on.

Structure of Organic Compounds

As an example of the application of these principles to the determination of the structure of a compound, the cases of ethyl alcohol and dimethyl ether may be cited. Both of these compounds have the molecular formula C_2H_6O and, therefore, the possible structures are :



It is found that sodium metal reacts readily with ethyl alcohol to form a compound of the formula $NaOC_2H_5$, and that once one H atom has been replaced by sodium, the other five cannot be displaced, however much sodium is added. It must be concluded, therefore, that one H atom is attached differently from the other five, and since the property of displacement of hydrogen by sodium is common to the OH grouping, it is obvious that this group occurs in ethyl alcohol.

These and other considerations led to the adoption of formula (1) for this substance. In dimethyl ether, on the other hand, all the six hydrogen atoms are equally difficult to remove, and from its chemical properties it was possible to decide that its molecule is graphically represented by formula (2).

Graphic or structural formulae are therefore of great importance in organic chemistry. It must be remembered, however, that these formulae are not true pictures of the arrangements of the atoms in the molecule ; they are merely projections in one plane, that is, two-dimensional diagrams.

LESSON 29

Organic Compounds of Carbon and Hydrogen

It has been shown in the preceding Lesson that in all its organic compounds carbon is quadrivalent, a fact which might have been expected from a knowledge of its electronic structure (*see* Lesson 12). The atomic number of carbon is 6 and therefore its electronic configuration is (2) (4) ; it thus has four valency electrons, which it can share with other atoms, forming four covalent links. One unique property of the carbon atom is that it is able to combine with other carbon atoms to an almost unlimited extent, and it is this tendency to combine with itself that leads to the formation of the almost endless number of carbon compounds.

The Hydrocarbons

Many of these compounds are composed of carbon and hydrogen only ; they are called *hydrocarbons* and must not be confused with the carbohydrates, which, as will be seen later, contain oxygen as well. Hydrocarbons may be divided into three classes :

(1) the paraffins
(2) the olefines
(3) the acetylenes

according as the molecule contains only single-bonded, one or more double-bonded, or triple-bonded carbon atoms. The first class is known as the *saturated*, the second and third as the *unsaturated, hydrocarbons.*

Aliphatic and Aromatic Compounds

There is still another group of hydrocarbons, the *aromatic* or *benzene hydrocarbons*, but these are structurally different and are placed in a separate category. In order to distinguish them from the aromatic hydrocarbons, the three types previously mentioned are referred to collectively as the *aliphatic* or straight-chained hydrocarbons.

Saturated Hydrocarbons (or Paraffins)

Dealing with saturated hydrocarbons or paraffins, the simplest compound of this class is methane or marsh gas, CH_4, which is frequently found bubbling out of the ground in marshes and other places where organic matter is decomposing under water. Methane is also found in coal-mines, and it is to mixtures of this gas—called firedamp—and air that explosions in mines are due. Ordinary coal-gas contains about 40 per cent. of methane. The gas can be prepared from the elements only with great difficulty—a temperature of at least 1,200° C. is necessary—but it can be readily obtained in the laboratory by heating in a hard glass retort a mixture of anhydrous sodium or potassium acetate and caustic soda or soda-lime. The equation for this is written :

$$CH_3COONa + NaOH \rightarrow \overset{\nearrow}{CH_4} + Na_2CO_3.$$

Properties of Methane

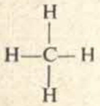
Methane is a colourless, odourless gas which is practically insoluble in water and burns in air with a pale blue, non-luminous flame. It is very stable and can be passed through bromine or nitric or sulphuric acid without undergoing any change. When mixed with chlorine gas and exposed to direct sunlight, it explodes, carbon being deposited and hydrogen chloride formed. In diffused light the reaction is much less violent and a mixture of four compounds is produced, one atom of chlorine successively replacing each of the atoms of hydrogen.

Substitution Products of Methane

The names of these compounds are : CH_3Cl, methyl chloride ; CH_2Cl_2, methylene dichloride ; $CHCl_3$, chloroform ; CCl_4, carbon tetrachloride ; and the amounts of each formed depend on the relative amounts of chlorine and methane present. Owing to the nature of their formation they are called *substitution products* of methane, mono-, di-, tri-, etc., according to the number of hydrogen atoms replaced by chlorine.

Substitution—and Saturation

This process of substitution brings out an important aspect of the structure of hydrocarbons of this type. Since this is the only way in which methane can react with another atom, it must be assumed that the carbon atom already has all its valency bonds satisfied with hydrogen atoms. This agrees with the formula CH_4, written graphically :



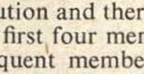
$$\begin{array}{c} H \\ | \\ H—C—H \\ | \\ H \end{array}$$

Such compounds, in which the maximum valencies of the carbon atoms are satisfied by single links, are called saturated ; their exceptional stability depends upon this fact.

The next simplest hydrocarbon of this type is ethane, C_2H_6, which also occurs in the gas which issues from the earth in the neighbourhood of petroleum deposits. It is prepared in the laboratory by the reduction of ethyl iodide with nascent hydrogen, produced by means of a zinc-copper couple and water.

Properties of Ethane

Ethane is a colourless, odourless gas which closely resembles methane and burns in air to produce carbon dioxide and water. Like methane it is a saturated compound and forms various substitution products with chlorine. Its formula is written :



$$\begin{array}{c} H\quad H \\ |\quad\; | \\ H—C—C—H \\ |\quad\; | \\ H\quad H \end{array}$$

or shortly $CH_3—CH_3$

so that it really consists of two methyl radicals.

Members of Paraffin Series

Methane and ethane are the first members of a long series of compounds which are very similar in constitution and therefore in chemical properties. The first four members are colourless gases, subsequent members are colourless liquids, whilst the highest members are white, wax-like solids. The first five members (pentane being a liquid) are :

Methane CH_4
Ethane C_2H_6
Propane C_3H_8
Butane C_4H_{10}
Pentane C_5H_{12}

Each member differs from its predecessor by CH_2, while the general formula for the *n*th member is C_nH_{2n+2}. Such a series, in which the members are similar in constitution and therefore in chemical properties, is called a homologous series.

Petroleum and the Paraffins

It has been mentioned that methane and ethane occur in the regions of petroleum deposits. Petroleum consists almost entirely of hydrocarbons, produced by the destructive distillation far below the earth's surface of the fatty remains of animals and of vegetable products. In many parts of the world, for example in Pennsylvania (U.S.A.) and south-east Russia, the natural gas which escapes from the oilfields is used as an industrial fuel. Petroleum oil is roughly separated into its constituent hydrocarbons by fractional distillation ; the first fractions obtained in this way are colourless, mobile liquids, having boiling-points from 40° to 70° and 70° to 90° C. ; they are used in petrol engines and as solvents. The second fractions, boiling points from 120° to 150° C., are used for cleansing purposes ; the third fraction, 150° to 300° C., called kerosene, is used as an illuminant, and the fractions boiling above 300° C. are used as lubricating oils and as "Vaseline". Paraffin wax is generally obtained by the destructive distillation of shale.

Olefine Series of Hydrocarbons

When the halogen mono-substitution products of the paraffins, such as ethyl bromide, are heated with an alcoholic solution of potash another type of hydrocarbon is obtained, thus :

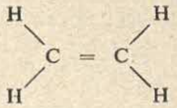
$$C_2H_5Br + KOH \rightarrow \overset{\nearrow}{C_2H_4} + KBr + H_2O.$$

Compounds of this type form a homologous series, analogous to that of the paraffins but having the general formula C_nH_{2n} ; they are called the *olefines* (olefiant, oil-making ; Lat. *oleum*, oil) because the lightest members react with chlorine to form oily liquids. The simplest member of this series is ethylene, C_2H_4, which occurs to the extent of about 6 per cent. in coal-gas. Besides the method already given for its preparation, ethylene can be readily prepared by the dehydration of ethyl alcohol by means of sulphuric or phosphoric acid. The equation may be written :

$$C_2H_5OH \rightarrow \overset{\nearrow}{C_2H_4} + H_2O.$$

Properties of Ethylene

Ethylene is a colourless gas, with a sweet smell ; it burns with a luminous flame and forms a highly explosive mixture with air or oxygen. Unlike the paraffins, it combines directly with many elements and compounds, such as H_2, Cl_2, HBr, etc., to form saturated addition compounds. For example, when passed into bromine it is rapidly absorbed, giving ethylene dibromide, $C_2H_4Br_2$, which is a colourless oil. As a result of its readiness to form addition compounds of this type (contrast the substitution products of the paraffins) ethylene has the constitution :



in which the two carbon atoms are linked by a double bond. The presence of the double bond enables the molecule to combine directly with univalent atoms or radicals ; it is therefore said to be unsaturated. When combination takes place, the double bond is broken and the atoms in the resulting saturated compound are then attached to one another by single valency links.

Acetylene Series

The third homologous series of hydrocarbons, having the general formula C_nH_{2n-2}, contains a triple-bonded carbon atom. The simplest member, acetylene, C_2H_2, occurs in very small quantities in coal-gas and is prepared quantitatively by the action of water on calcium carbide, according to the equation,

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2.$$

Acetylene can also be prepared by causing an electric arc to pass between two carbon poles in an atmosphere of hydrogen. This method is important, since acetylene can be readily reduced to ethylene, which can be converted into ethyl alcohol, the basis of the preparation of many organic substances.

Properties of Acetylene

Acetylene is a colourless gas with a garlic-like smell ; it is highly inflammable and burns with a hot, smoky flame, due to the large percentage of carbon which it contains. With suitable burners its flame becomes dazzlingly white and it has some use as an illuminant. When passed into an ammoniacal solution of cuprous chloride or silver nitrate, acetylene produces insoluble compounds, called copper and silver acetylides, Cu_2C_2 (red), and Ag_2C_2 (white), which are violently explosive and detonate when rubbed or touched. Acetylene combines readily with hydrogen in the presence of finely divided nickel, giving first ethylene and finally ethane. Similarly it forms addition compounds with the halogens, sometimes with explosive violence, for example :

$$C_2H_2 + 2Cl_2 \rightarrow \underset{\text{tetrachlorethane}}{\overset{\nearrow}{C_2H_2Cl_4}}.$$

From a consideration of these and other chemical properties it has been proved that acetylene has the constitution H—C≡C—H, in which the carbon atoms are attached to each other by a triple bond. All the compounds of the acetylene series have a linkage of this kind and their chemical properties are similar.

LESSON 30

The Alcohols and Their Derivatives

When methyl chloride is prepared as described in the preceding Lesson, by the reaction of a large excess of methane with chlorine, and is heated in a closed vessel with a dilute aqueous solution of potassium hydroxide, a colourless, mobile liquid, possessing a wine-like odour and a burning taste, is produced. This is called methyl alcohol, CH_3OH, the equation for its formation being

$$CH_3Cl + KOH \rightarrow KCl + CH_3OH$$

Methyl alcohol is the first member of a homologous series of hydroxide-like compounds, each of which can be prepared from the corresponding member of the analogous paraffin series in this way.

Preparation of Methyl Alcohol

Methyl alcohol is prepared on a large scale by heating wood in iron retorts out of contact with the air ; water, methyl alcohol, acetic acid, tar, and some volatile hydrocarbons condense in the receivers and are separated first by the addition of lime, which removes the acetic acid, and then by filtration through charcoal and fractional distillation. This partially purified methyl alcohol is usually known as wood spirit. Methyl alcohol burns with a pale blue non-luminous flame, producing carbon dioxide and water ; it dissolves many solid organic compounds and for this reason has an important commercial use as a solvent for dyes, gums, resins, varnishes, and so on. It is also used to render ethyl alcohol, employed for commercial purposes, unfit for drinking ; methylated spirit contains about 90 per cent. of aqueous ethyl alcohol and about 10 per cent. of partially purified wood spirit.

Properties of Methyl Alcohol

The chemical properties of methyl alcohol, and, in fact, of all the members of the alcohol series, are to some extent characteristic of the properties of the OH radical. Like water, it reacts vigorously with sodium or potassium metal, forming unstable, salt-like compounds called methoxides or methylates, thus :

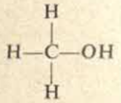
$$2CH_3OH + 2Na \rightarrow 2CH_3ONa + H_2\nearrow$$

Also, though neutral to litmus, alcohols behave like weak bases in the presence of strong acids such as HCl, giving a class of compounds analogous to inorganic salts and called esters. Thus, with HCl, methyl chloride is formed—

$$CH_3OH + HCl \rightarrow CH_3Cl + H_2O.$$

It has been mentioned that when vigorously oxidised by being burnt in air, methyl alcohol is completely decomposed into carbon dioxide and water. Less vigorous oxidation, as, for example, with nitric or chromic acid or potassium permanganate, results in the production of new products without the disruption of the molecule. If one atom of oxygen is added—that is, if two atoms of hydrogen are removed—the resulting product is formaldehyde, CH_2O ; if another oxygen atom is added, formic acid, CH_2O_2, is produced.

From a consideration of the valencies of the atoms in the molecule and also of the chemical properties of methyl alcohol, it has been proved that its structure may be represented thus :



$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-OH$$

This type of structure, in which one OH radical is attached to a carbon atom to which are also attached either hydrogen atoms or univalent radicals such as the methyl radical, CH_3, is common to all the alcohols of this series ; they are called the monohydric alcohols. If the C atom, to which the OH group is attached, has two H atoms, the alcohol is called a primary alcohol ; if the C atom has only one H atom and 2 univalent radicals, the alcohol is called a secondary alcohol, and so on.

Ethyl Alcohol

The next member of the monohydric series is ethyl alcohol, C_2H_5OH, usually known merely as alcohol. Because of its method of preparation by fermentation, alcohol is sometimes called spirits of wine. When grape-juice is kept for a short time under fairly warm conditions, the sugars, glucose, and fructose which it contains are decomposed into alcohol and carbon dioxide :

$$\underset{\text{glucose}}{C_6H_{12}O_6} \rightarrow \underset{\text{alcohol}}{2C_2H_6O} + 2CO_2\nearrow.$$

Alcoholic Fermentation

This process is called alcoholic fermentation. It is brought about, or catalysed, by living vegetable organisms, present in the grapes, called ferments : the particular ferment active in this case is yeast or saccharomyces. It is not the yeast itself which causes the decomposition of the sugar but substances called enzymes—zymase, maltase, and invertase—which are present in it. During the process of fermentation the yeast multiplies rapidly by growing buds on its rounded cells (gemmation) and forms a scum on the surface of the fermenting liquid.

Enzymes are very complex nitrogenous substances, and since their catalytic properties appear to cease after they have been raised to higher temperatures, fermentation must be carried out between 5° and 30° C.

The chief source of beer is barley malt ; when the grain is moistened with water and exposed to the air it begins to germinate, producing during the process an enzyme called diastase. The grain in this state is called malt and consists mainly of starch, which is another carbohydrate having the same general formula as sugar. The germination is then stopped by raising the temperature to between 50° and 100° C., and the malt is stirred up with water and kept at about 60° C., when, as a result of the catalytic action of the diastase, the starch is converted into sugars resembling glucose. Hops (the flowers of the hop plant) are then added to give flavour, and yeast to start the alcoholic fermentation. Beer usually contains about 3–6 per cent. of alcohol, small quantities of starch, sugars, and colouring matter, as well as carbon dioxide produced during fermentation, to which it owes its refreshing qualities.

Spirits and Wine

Spirits are produced by the distillation of alcoholic liquors ; whisky is obtained from barley-malt liquors ; brandy from grape-juice ; rum from fermented molasses. The amounts of alcohol (per cent. by weight) present in these and other alcoholic beverages are given in the following table :

Brandy	60%	Port	20%	Claret	7%
Rum	60%	Sherry	16%	Burton ale	6%
Whisky	50%	Hock	9%	Beer	5%
Gin	40%	Bordeaux	8%	Lager	4%

Alcohol for industrial purposes is prepared on a large scale by the fermentation of potatoes, grain, and other substances rich in starch or sugar. The diastatic fermentation is allowed to proceed as described above, and the liquor subjected to fractional distillation ; the distillate containing 80 to 90 per cent. of alcohol is called raw spirit and can be concentrated by further fractionation. The strength of a sample is usually estimated by measurement of specific gravity or density and reference to standard tables. The standard of reference for the strength of spirits is called *proof spirit*, and contains 49·3 per cent. by weight or 57·1 per cent. by volume of alcohol ; liquors containing more or less than this amount are said to be " over proof " or " under proof " respectively. Thus, 20 per cent. under proof means that 100 volumes of this particular sample contain as much alcohol as 80 volumes of proof spirit.

It has been mentioned that when methyl alcohol is gently oxidised, a compound called formaldehyde, having the formula CH_2O, is first produced. This substance is usually prepared by passing a stream of air, saturated with alcohol vapour, through a tube containing a copper spiral or platinised asbestos heated to redness. The pungent-smelling liquid which collects in the receiver contains 30 per cent. of formaldehyde with methyl alcohol and water.

Properties of Formaldehyde

Formaldehyde is a gas at ordinary temperatures, but it polymerises slowly to form ultimately a white solid called paraformaldehyde. Aqueous solutions are strong-smelling and neutral to litmus.

Owing to the readiness with which formaldehyde undergoes oxidation to formic acid it is a strong reducing agent ; if added to an ammoniacal solution of a silver salt, for example, it reduces the salt to metallic silver, which is deposited in the form of a shiny mirror. Formaldehyde is a strong antiseptic ; and as formalin, a solution of about 40 per cent. in water, it is used for this purpose.

Acetaldehyde (or " Aldehyde ")

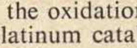
Acetaldehyde, C_2H_4O, usually known merely as aldehyde, is the next member of the aldehyde series. It is prepared in a similar manner to formaldehyde by the oxidation of ethyl alcohol by means of a platinum catalyst or potassium dichromate and sulphuric acid. It is a colourless, volatile liquid of boiling point about 21° C. with a characteristic penetrating smell. Like formaldehyde it polymerises to form paraldehyde, is a strong reducing agent, and is readily oxidised to acetic acid. It combines directly with sodium bisulphite to form a colourless, crystalline compound, and also with ammonia.

Formation of Aldehydes and Ketones

Aldehydes are formed by the oxidation of the appropriate primary alcohol, two atoms of hydrogen being removed in each case, thus :

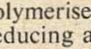
$$C_2H_5OH - H_2 \rightarrow C_2H_4O.$$

From a consideration of the properties of these compounds it was shown that one of the hydrogen atoms comes from the OH group ; the constitution of acetaldehyde is therefore represented graphically thus :



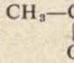
$$H_3C-C\begin{matrix}\diagup H\\ \diagdown O\end{matrix}$$

and it is to the univalent aldehyde-group,



$$-C\begin{matrix}\diagup H\\ \diagdown O\end{matrix}$$

which is common to all aldehydes, that the characteristic chemical properties of this class of compounds are due.

When a secondary alcohol, such as iso-propyl alcohol, $CH_3CH(OH)CH_3$, is oxidised, a substance called a ketone is formed. This reaction is analogous to that which takes place in the formation of aldehydes, and because of their structural similarity aldehydes and ketones have somewhat similar properties. Acetone is the most important ketone ; it is prepared by the oxidation of iso-propyl alcohol with potassium dichromate and sulphuric acid, and has the formula  $CH_3—C(=O)—CH_3$. The divalent group $>C=O$ is common to all ketones. Like aldehyde, acetone combines with sodium bisulphite ; but it does not polymerise, nor does it reduce silver solutions of silver salts to metallic silver. Moreover, it is oxidised only with difficulty, and when oxidised it decomposes into carbon dioxide and water. Acetone is prepared commercially, by dry distillation of calcium or barium acetate, thus :

$$(CH_3COO)_2Ca \rightarrow CH_3COCH_3 + CaCO_3.$$

It is a colourless, mobile liquid which, like alcohol, dissolves many organic compounds and is used in industry as a solvent for gums, varnishes, resins, etc.

LESSON 31

Ether, the Fatty Acids, and Their Products

In some respects the alcohols resemble the hydroxides of the metals, for example, in reacting with an acid to form esters which are analogous to inorganic salts, thus :

$$CH_3OH + HCl \rightarrow CH_3Cl + H_2O.$$

Univalent groups or radicals such as CH_3, C_2H_5, and so on, may therefore be looked upon as being somewhat analogous to the metals, and are referred to as *alkyl* groups. If these alkyl groups are so like metals as to form hydroxides, they might also be expected to form oxides. This is indeed the case, the term *ether* being the generic name used to refer to such organic oxides. The simplest of the ethers is methyl ether, also called di-methyl ether, which is written $CH_3.O.CH_3$, and is obtained when one molecule of water is removed from two molecules of methyl alcohol (CH_3OH). Similarly, ethyl ether has the formula $C_2H_5.O.C_2H_5$; methyl ethyl ether, $CH_3.O.C_2H_5$, and so on ; the general formula of the type being $R.O.R_1$, where R and R_1 may be the same or different alkyl groups.

Ethyl Ether

Ethyl ether, usually called simply ether, is prepared by heating ethyl alcohol with concentrated sulphuric acid at about 140° C. In order to keep up a continuous stream of ether, which distils over and condenses in the receiver, alcohol is added continuously to the distilling flask by a dropping funnel. The reaction proceeds in two stages, the first being the conversion of some of the alcohol into the ester, ethyl hydrogen sulphate, according to the equation

$$C_2H_5OH + H_2SO_4 \rightarrow C_2H_5HSO_4 + H_2O.$$

This compound then reacts with excess of alcohol thus :

$$C_2H_5HSO_4 + C_2H_5OH \rightarrow C_2H_5.O.C_2H_5 + H_2SO_4.$$

Theoretically, therefore, a small amount of sulphuric acid should convert an unlimited quantity of alcohol into ether ; this is, however, not realized in practice, since the acid is constantly being diluted by the water formed in the first stage. This process of manufacturing ether by the dehydration of the corresponding alcohol by means of sulphuric acid can be applied quite generally ; it is known as the continuous etherification process. Ether may also be prepared by warming a mixture of sodium ethylate and ethyl iodide. The reaction,

$$C_2H_5.O.Na + I.C_2H_5 \rightarrow NaI + C_2H_5.O.C_2H_5,$$

is of theoretical importance, as it enabled the constitution of ether to be decided upon.

Properties of Ether

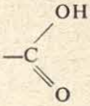
Like most of this series of compounds, ether is a colourless, mobile liquid which boils at about 35° C. The vapour which it gives off at this very low temperature is, like the liquid itself, extremely inflammable, so that there is considerable danger in handling ether near an unshielded flame. When inhaled, ether produces insensibility, and it is used as an anaesthetic in surgery. It dissolves resins, fats, oils, etc., and it is used as a solvent in industrial chemistry. Unlike alcohol, it is comparatively unreactive ; it is not acted upon by sodium or potassium metals, and is quite stable to acids when cold.

The Fatty Acids

It has been mentioned that the complete oxidation (without decomposition) of methyl and ethyl alcohols leads to the formation of formic and acetic acids respectively. The relation of these two compounds to the paraffins, the alcohols, and the aldehydes is shown below :

Paraffins	Alcohols	Aldehydes	Acids
$H.CH_3$ $CH_3.CH_3$	$H.CH_2.OH$ $CH_3.CHO_2.H$	$H.CHO$ $CH_3.CHO$	$H.CO.OH$ $H_3.CO.OH$

Formic and acetic acids are the first members of a homologous series of acids known as the fatty acids, because many of the higher members occur in the combined state in natural fats. Just as the grouping –CHO is common to the aldehydes, so the univalent group



is common to all acids of this series and, in fact, is responsible for their characteristic properties ; it is called the carboxylic group.

Formic Acid

Formic acid occurs in nature in ants (*Formicae*), from which it derives its name, and in nettles ; the irritation caused by the sting of the nettle is partly due to this acid. Its preparation by the oxidation of methyl alcohol or formaldehyde under the catalytic influence of platinum black has already been mentioned. Formic acid is a colourless, mobile liquid with a pungent smell ; it behaves like a weak monobasic mineral acid, turning litmus red, and reacting with alkalis to form salts called formates, e.g. sodium formate, H.CO.ONa. Only one hydrogen atom, namely that in the carboxylic group, is replaceable by the metal. When mixed with concentrated sulphuric acid, formic acid is rapidly decomposed into carbon monoxide and water, according to the equation

$$\mathrm{H.CO.OH} \rightarrow \mathrm{CO} + \mathrm{H_2O}$$

The reaction therefore consists merely in the removal of the elements of water by the sulphuric acid.

Acetic Acid

Acetic acid ($\mathrm{CH_3.CO.OH}$) occurs in nature combined with alcohols in the essences or volatile oils of many plants. It is obtained in large quantities as a by-product in the extraction of wood spirit (*see* Lesson 30) by the destructive distillation of wood, also by the oxidation of ethyl alcohol or acetaldehyde. When a weakly alcoholic liquor, such as wine or beer, is left exposed to the air for any length of time it rapidly becomes sour owing to the formation of acetic acid. The reaction,

$$\mathrm{C_2H_5OH} + \mathrm{O_2} \rightarrow \mathrm{CH_3COOH} + \mathrm{H_2O}$$

is really brought about by a ferment called *Mycoderma aceti*. As the ferment is killed by strong alcohol, the process takes place only in weakly alcoholic liquors ; the fermented solution, containing about 6 to 10 per cent. of acetic acid, is called vinegar.

Pure anhydrous acetic acid is obtained by distilling anhydrous sodium acetate with concentrated sulphuric acid ; it condenses into a colourless, crystalline solid, which is called glacial acetic acid to distinguish it from the hydrated liquid form. It has an acrid, penetrating smell and readily dissolves most organic compounds, and many inorganic substances such as sulphur, iodine, etc. Like formic acid, it behaves as a monobasic acid, and reacts with hydroxides and carbonates to form stable, crystalline salts called acetates. These are soluble in water and are decomposed by mineral acids, with liberation of acetic acid. The presence of acetic acid, or an acetate, is readily shown by warming the substance for analysis with a few drops of alcohol and a little concentrated sulphuric acid. If an acetate is present, ethyl acetate, a volatile fruity-smelling ester, is evolved.

Higher Homologues of Acetic Acid

All the acids of this series resemble formic and acetic acids in methods of preparation, chemical properties, etc. They are all monobasic, the hydrogen atom of the carboxylic group being the only one replaceable by a univalent metal. Of the higher acids, three are of considerable importance because of the part they play in the composition of certain familiar natural products. Butyric acid, in combination with glycerol, is an important component of butter ; palmitic and stearic acids, with the closely allied oleic acid, form part of all natural oils and fats. Waxes are esters of fatty acids with long chain alcohols.

Butyric Acid

Butyric acid, $\mathrm{C_3H_7COOH}$, may be obtained from butyl alcohol, but it is most commonly known as a characteristic product of the fermentation of lactic acid with bad or fermented cheese. When, for example, milk is left exposed to the air, fermentation sets in, and the lactose, or milk sugar, is converted into lactic acid, which gives the milk its sour taste. If now a little bad cheese is added, and the liquid kept neutral by the addition of calcium carbonate, butyric fermentation starts. The mechanism of these processes was studied by the French chemist Louis Pasteur (1822–95), who showed that each of the changes is due to a special ferment—in the first place, the lactic ferment and in the second, the butyric ferment. When lactic acid is converted into butyric acid in this way, hydrogen is also produced.

Palmitic and Stearic Acids

Palmitic ($\mathrm{C_{15}H_{31}COOH}$) and stearic ($\mathrm{C_{17}H_{35}COOH}$) acids occur in combination with glycerol in all vegetable and animal oils and fats, such as palm oil, and beef and mutton fats ; they are prepared on a large scale from these sources chiefly for the manufacture of stearin candles and of soaps.

When a fat or oil, which consists of the glycerin ester of a fatty acid, is decomposed by means of superheated steam, a process takes place which is called saponification and which is analogous to the hydrolysis of certain inorganic salts. Just as hydrolysis leads to the formation of a base and an acid, so saponification of a fat leads to the formation of glycerin and the fatty acid. This reaction proceeds much more rapidly if caustic soda be added, as the fatty acid is then converted into the sodium salt and removed as fast as it is formed. Such a sodium (or potassium) salt of these higher fatty acids is called a *soap*.

In the manufacture of soaps the fats are boiled with caustic soda, and the soap floats to the surface and is allowed to set in moulds ; the valuable glycerin may be recovered from the residue. If caustic potash is used, soft soap is obtained. As a rule commercial soap contains a small amount of free alkali, which greatly adds to the cleansing properties.

Acid Chlorides

Two classes of compounds derived from the fatty acids are of considerable importance ; the first of these is the acid chlorides, of which *acetyl chloride*—$CH_3.CO.Cl$—is the best example. This compound, a colourless pungent liquid which boils at 55° C., is formed when phosphorus pentachloride is added to anhydrous acetic acid, the OH group being replaced by chlorine. Acetyl chloride reacts vigorously with water and, in fact, with any compounds which contain the OH group ; e.g. with alcohol the univalent acetyl group CH_3CO- displaces the hydrogen of the hydroxyl group and ethyl acetate is formed, by the equation,

$$C_2H_5OH + CH_3COCl \rightarrow CH_3COOC_2H_5 + HCl.$$

For this reason acetyl chloride is used to detect the presence of a hydroxyl group in an organic compound. Acetyl chloride also reacts with anhydrous ammonia to give a compound called *acetamide*, thus :

$$CH_3.CO.Cl + NH_3 \rightarrow CH_3.CO.NH_2 + HCl.$$

Acetamide may be regarded as a derivative of ammonia in which one hydrogen atom has been replaced by the acetyl group ; it is a colourless, crystalline solid which, owing to the presence of impurities, usually has a strong smell of mice.

All the members of the fatty acid series give amides of this type ; their chemical properties are similar and are mainly determined by the presence in the molecule of the univalent amide grouping, $-CO.NH_2$.

Chloroacetic Acids

When acetic acid is heated with chlorine in the presence of strong sunlight, which acts as a catalyst, or of iodine, which acts as a chlorine carrier, each of the three hydrogen atoms in the CH_3 group may be replaced by a chlorine atom. These chloroacetic acids are analogous to the chlorine substitution products of methane and have the formulae :

$CH_2.Cl.COOH$	chloroacetic acid
$CH.Cl_2.COOH$	dichloroacetic acid
$CCl_3.COOH$	trichloroacetic acid

As might be expected since they all contain the carboxylic group, these acids resemble the monocarboxylic acids in chemical properties and, like acetic acid, form salts, acid chlorides, etc. They are of considerable importance in synthetic chemistry, as it is possible through replacing the chlorine atoms by other radicals or groups to build up complicated organic compounds.

The Esters

It has been mentioned that in some respects the alcohols behave like weak metallic hydroxides, reacting with concentrated acids to form esters which are analogous to inorganic salts. For example :

$$CH_3OH + HCl \rightleftharpoons CH_3Cl + H_2O ;$$
$$C_2H_5OH + H_2SO_4 \rightleftharpoons C_2H_5HSO_4 + H_2O.$$

It is important to notice that these reactions are reversible and that in the presence of water the esters are hydrolysed with the production of alcohol and acid. The reaction is therefore usually carried out in the presence of a substance such as sulphuric acid or zinc chloride (Groves' Process), which removes the water as it is formed and causes the equilibrium to be displaced towards the right in the above equation.

Chloroform

Chloroform, or trichloromethane, $CHCl_3$, which is prepared by distilling dilute aqueous alcohol or acetone with bleaching powder, is a most important halogen ester of methyl alcohol. The chloroform collects as a heavy oil, and may be separated from the impurities, alcohol, acetone, water, etc., with the aid of a separating funnel and purified by redistillation. Chloroform is a colourless, mobile, refractive liquid which is used in surgery as an anaesthetic. On prolonged exposure to light and air it tends to decompose, and it yields among other substances chlorine and hydrochloric acid. Impurities of this kind are physiologically dangerous, and chloroform for inhalation purposes must be protected from air and light. Pure chloroform gives no opalescence with silver nitrate solution.

Bromine and iodine also form esters of this type ; *bromoform*, $CHBr_3$, is too dangerous to be used as a drug, but *iodoform*, CHI_3, a yellow crystalline solid, is used in medicine and surgery, and as an antiseptic.

Carbon tetrachloride, CCl_4, a heavy colourless liquid with a sweet smell, is prepared in large amounts by chlorinating carbon disulphide in the presence of aluminium chloride, which acts as a chlorine carrier. Because of its noninflammable nature it is used as a fire-extinguisher ; the liquid is kept in small cylinders and a stream, under pressure, is directed at the seat of the flame. The vapour from the liquid forms a blanket which prevents combustion.

The halogen mono-substitution products of ethane are usually prepared by the action of the phosphorus penta-halide on ethyl alcohol. The reaction in the case of ethyl chloride is written :

$$C_2H_5OH + PCl_5 \rightarrow C_2H_5Cl + POCl_3 + HCl.$$

These three compounds, ethyl chloride, bromide, and iodide, are colourless, volatile, pleasant-smelling liquids, which hydrolyse when heated with caustic potash, yielding ethyl alcohol and hydrochloric acid. When boiled with alcoholic potash, on the other hand, they are converted into olefines, thus :

$$C_2H_5I + KOH \rightarrow KI + C_2H_4 + H_2O.$$

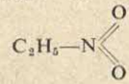
Like methyl chloride (boiling point 23·7° C.), ethyl chloride has a low boiling point (12·2° C.), and because of the freezing effect caused by the rapid evaporation in spray form it is used as a local anaesthetic.

Esters of Nitrous Acid

Esters of nitrous acid are of considerable importance, since it has been proved that two distinct types of chemical compound exist, both of which have a composition corresponding to the formula $R.NO_2$, where R may be any alkyl group. For example, when ethyl alcohol is distilled with nitrous acid—or a mixture of sodium nitrite and sulphuric acid—a colourless liquid, with a pleasant, fruity smell and a boiling point of 17° C., is formed. It is called *ethyl nitrite*, is insoluble in water, and is readily hydrolysed by dilute alkalis, yielding ethyl alcohol. If, on the other hand, ethyl iodide is warmed with silver nitrite and the liquid product fractionated, two substances are obtained, one of which boils at 17° C. and is identical with ethyl nitrite, while the other—which is called *nitroethane*—boils at 114° C. and has quite different properties. For example, it dissolves in, but is not decomposed by, caustic alkali, and while the nitrite, when reduced with hydrogen, usually yields ammonia and alcohol, nitroethane is converted into a compound called an *amine*—in this case ethylamine. From a consideration of these and other chemical properties it was possible to decide on the arrangements of the atoms in the molecule in each case ; the substances are represented constitutionally thus :

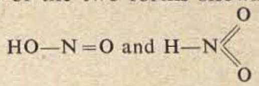
ethyl nitrite $C_2H_5.O—N=O$

nitroethane



$$C_2H_5{-}N\Big\langle\begin{matrix}O\\O\end{matrix}$$

It has been shown that nitrous acid (HNO_2) is a mixture of the two forms shown below :

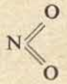


$$HO{-}N{=}O \text{ and } H{-}N\Big\langle\begin{matrix}O\\O\end{matrix}$$

and the compounds above are obtained by replacing the hydrogen atom with an ethyl group.

Nitro-Paraffins

Substances like these which have the same chemical composition but different chemical and physical properties are called *isomers.* There exists a complete series of compounds which are similar to nitroethane and which can be prepared from the halogen esters and silver nitrite in a similar way ; they are called the *nitro-paraffins*, and their chemical reactions are characteristic of the reactions of the univalent nitro group—



$$N\Big\langle\begin{matrix}O\\O\end{matrix}$$

Nitromethane is one of the most important ; it is a colourless, pleasant-smelling liquid of boiling point about 101° C. and it has some use as a solvent of organic substances.

The alcohols also react under suitable conditions with nitric acid to give nitrates, with sulphuric acid to give hydrogen sulphates and sulphates, both of which are analogous to the corresponding inorganic compounds, and also with organic acids such as acetic acid to give esters. These organic esters are hydrolysed by aqueous mineral acids and alkalis and give amides with concentrated ammonia. Some occur in the fruit and flowers of plants, and it is to their presence that the sweet scents are due ; *amyl acetate*, $CH_3.CO.OC_5H_{11}$, the acetyl ester of amyl alcohol, can be easily prepared and is used for flavouring sweets and cakes.

Amines

The alcohols and ethers may be regarded as derivatives of water formed by the substitution of one or two alkyl radicals for the hydrogen atoms. In a similar manner the hydrogen atoms of the ammonia molecule may be replaced by alkyl groups or other organic radicals giving an important group of strongly basic substances known as amines ; these may be of three types according as one (primary amine), two (secondary) or three (tertiary) hydrogen atoms have been displaced :

CH_3NH_2	$(CH_3)_2NH$	$(CH_3)_3N$
Methylamine	Diethylamine	Triethylamine
(primary)	(secondary)	(tertiary)

All of these compounds may be prepared by heating alcoholic ammonia with the alykl iodide, and it is sometimes possible to separate the resulting mixture of amines chemically. A better method of preparing the primary amines is to reduce the corresponding nitro compounds.

Like ammonia, these three amines are strongly basic ; in the presence of hydrochloric acid, for example, they form a series of additive salts, which have the composition :

$C_2H_5NH_2.HCl \qquad (C_2H_5)_2.NH.HCl \qquad (C_2H_5)_3N.HCl$

and are known as ethylamine hydrochloride and di- and triethylamine hydrochloride. Also, as might be expected by analogy with ammonium $[NH_4]$ salts, the fourth hydrogen atom of the triamine salt is replaceable by an alkyl group giving a quaternary ammonium salt, such as $(C_2H_5)_4.NCl$, tetraethyl ammonium chloride.

The three types of amine may be distinguished by their reactions with nitrous acid. Primary compounds yield the corresponding alcohol, nitrogen, and water, thus :

$$C_2H_5.N \boxed{H_2 + O} N.OH \rightarrow C_2H_5.OH + N_2 + H_2O$$

Secondary amines give yellow oils known as nitrosamines :

$$(C_2H_5)_2N \boxed{H + HO} NO \rightarrow (C_2H_5)_2N.NO + H_2O$$

Tertiary amines do not react with nitrous acid.

LESSON 32

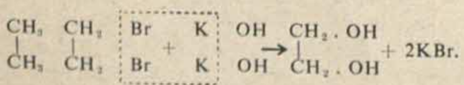
Secondary and Tertiary Alcohols

The series to which ordinary alcohol belongs are more properly called the primary alcohols. There are also secondary and tertiary alcohols, according as two or three instead of one hydrogen atom of methyl alcohol (CH_3OH) are replaced by alkyl groups ; and we have seen that while the first oxidation products of the primary alcohols are aldehydes, those of the secondary alcohols, such as iso-propyl alcohol, are ketones. All of these alcohols, primary, secondary, or tertiary, contain only one hydroxyl radical ; they therefore belong to a particular class called the *monohydric alcohols.*

Since all the hydrogen atoms in a paraffin, such as ethane, for example, bear the same relation to the carbon atoms, it might be expected that more than one could be replaced by a hydroxyl radical. This is the case, the resulting compounds being polyhydric alcohols ; of these the dihydric and trihydric alcohols are the most important ; they form well-defined series of compounds, which show a close relationship to those of the monohydric alcohols.

Dihydric Alcohols (Glycols)

The dihydroxy derivatives of the paraffins, discovered by the French chemist Carl Würtz (1817–84) in 1856, known as the glycols, form a homologous series of the general formula $(C_nH_{2n}OH)_2$. Of these, ethylene glycol $(CH_2OH)_2$, is the simplest ; it is formed when ethylene is cautiously oxidised with alkaline potassium permanganate solution, and is prepared in quantities by heating ethylene dibromide with dilute aqueous alkalis or alkaline carbonates. Its structural relationship to ethane is shown in its method of formation :

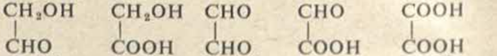


$$\begin{array}{c} CH_3 \\ | \\ CH_3 \end{array} \quad \begin{array}{c} CH_2 \\ | \\ CH_2 \end{array} \boxed{\begin{array}{ccc} Br & & K \\ & + & \\ Br & & K \end{array}} \begin{array}{c} OH \\ \\ OH \end{array} \rightarrow \begin{array}{c} CH_2.OH \\ | \\ CH_2.OH \end{array} + 2KBr.$$

Ethylene glycol (Greek · *glykys*=sweet) is a thick, colourless liquid with a sweetish taste. It mixes with water and alcohol in all proportions, but is only sparingly soluble in ether ; it boils at about 197° C., so that the introduction of the second hydroxyl radical into the ethyl alcohol molecule considerably raises the boiling point. Chemically, it behaves like a di-primary alcohol, reacting with sodium metal to form a mono- and a di-sodium derivative and with acids to form mono- and di- esters.

For example, when hydrogen chloride is passed into glycol heated to 100° C., ethylene chlorohydrin, $CH_2Cl.CH_2OH$, is formed, while at higher temperatures the second hydroxyl is displaced, giving ethylene dichloride. The di- esters are also formed with acetyl chloride and with phosphorus pentahalide.

The oxidation products of glycol are interesting ; each of the $-CH_2OH$ groups may be oxidised first to an aldehyde group, $-CHO$, and finally to a carboxylic group, $-COOH$, giving a variety of products thus :



$$\begin{array}{c} CH_2OH \\ | \\ CHO \end{array} \quad \begin{array}{c} CH_2OH \\ | \\ COOH \end{array} \quad \begin{array}{c} CHO \\ | \\ CHO \end{array} \quad \begin{array}{c} CHO \\ | \\ COOH \end{array} \quad \begin{array}{c} COOH \\ | \\ COOH \end{array}$$

glycollic aldehyde — glycollic acid — glyoxal — glyoxylic acid — oxalic acid

Of these, the first, which is a hydroxy aldehyde, is obtained by gentle oxidation of glycol with hydrogen peroxide in the presence of a ferrous salt ; the other products are formed by oxidation with nitric acid.

Hydroxy-Carboxylic Acids

Glycollic acid is acetic acid in which one hydrogen atom has been replaced by a hydroxyl group ; it is therefore hydroxy-acetic acid. $CH_2(OH).COOH$. It is prepared by boiling the potassium salt of chloroacetic acid with water, a reaction similar in nature to the formation of ethyl alcohol from ethyl chloride. Since it contains both a carboxylic group and a hydroxyl group, glycollic acid behaves as a mono-basic acid and also as a primary alcohol. Thus, like the fatty acids, it forms salts with th metallic hydroxides and esters with the alcohols, while, on the other hand, like the alcohols, it contains one hydrogen atom (that of the OH group) which may be replaced by a metal or an acetyl group. Glycollic acid is the first member of a homologous series of acids of this type, each of which may be regarded as an oxidation product of the corresponding glycol, or derivatives of the corresponding fatty acid. Carbonic acid or hydroxy-formic acid, HO.COOH, is really the lowest member, but exists only in dilute aqueous solution.

Hydracrylic Acid

The third member is hydroxy-propionic acid, and since in propionic acid, $CH_3.CH_2.COOH$, there are two alternative carbon atoms to which the OH group may be attached, two isomeric forms of this acid are known. These are distinguished by the Greek letters alpha and beta, according as the OH group is attached to the carbon atom nearer to the carboxyl group or to the one farther away. β-hydroxy-propionic acid, usually known as hydracrylic acid, $CH_2OH.CH.COOH$, is relatively unimportant; it can be obtained by boiling β-chloro-propionic acid, $CH_2Cl.CH_2.COOH$, with water; when oxidised by chromic acid, the $—CH_2OH$ group is converted into —COOH, yielding malonic acid, $COOH.CH_2.COOH$.

Lactic Acid

α-hydroxy-propionic acid or lactic acid, $CH_3.CHOH.COOH$, is a substance of great interest. It derived its name because of its production during the lactic fermentation of the sugars and starches in milk (*see* Lesson 31). The chemistry of the souring of milk may be represented empirically by the equation,

$$\underset{\text{lactose or milk sugar}}{C_{12}H_{22}O_{11}} + H_2O \rightarrow \underset{\text{lactic acid}}{4C_3H_6O_3}$$

and that of the butyric fermentation, studied by Pasteur, thus:

$$2C_3H_6O_3 \rightarrow C_4H_8O_2 + 2CO_2 + 2H_2.$$

Lactic acid may also be obtained by heating α-chloro-propionic acid with water or dilute aqueous alkalis (*cf.* glycollic acid). Like the other carboxylic acids, lactic acid behaves as a mono-basic acid, forming metallic salts called lactates, e.g. $Ca(C_3H_5O_3)_2.5H_2O$. It differs from hydracrylic acid in containing the $>$CHOH group, and thus shows many reactions of a secondary alcohol.

Optical Isomerism and Lactic Acid

The chief interest in lactic acid lies in the fact that it exists in three forms, all of which possess the same structural formula and are almost identical in chemical and physical properties. They can, however, be distinguished by the use of plane polarised light. Thus, when a ray of polarised light is passed through a layer of lactic acid obtained from sour milk it emerges without any appreciable alteration. This form of the acid is therefore said to be *optically inactive*. If, however, we take muscular tissue, such as that contained in meat extract, and treat it suitably, we can obtain another form of lactic acid which differs from the sour milk acid in rotating the plane of polarised light towards the right. It is therefore said to be *optically active*, and since it rotates the light plane to the right, is called dextro-rotatory. It is known as *sarco-lactic acid* (Gk. *sarx*=flesh) or *d*-(dextro) lactic acid.

Examination of optically inactive lactic acid revealed the fact that it consists of a mixture of dextro-rotatory acid and another form, identical chemically, but one that causes polarised light to be deviated in the opposite direction, that is, to the left hand. This form is therefore known as laevo-rotatory or simply *l*-lactic acid. The optical rotations of *d*- and *l*-lactic acids are the same but they take place in opposite senses. These three forms of lactic acid provide one of the simplest examples of what is known as *optical isomerism*.

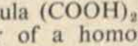
Oxalic Acid

Glycollic acid is produced when one of the $—CH_2OH$ groups of ethylene glycol is oxidised to —COOH; if both $—CH_2OH$ groups are oxidised to COOH, the resulting product is oxalic acid, formula $(COOH)_2$. Oxalic acid is the first member of a homologous series of dibasic acids, called the di-carboxylic acids; it occurs in rhubarb and other plants such as dock and sorrel, usually in the form of the potassium or calcium salts.

It is prepared by oxidising glycol, cane sugar, or sawdust with nitric acid or atmospheric oxygen. Oxalic acid is a white, crystalline solid, which dissolves readily in alcohol and fairly readily in water. When heated alone, or with concentrated sulphuric acid, oxalic acid decomposes into CO, CO_2 and water. It is a dibasic acid and reacts with bases to form both acid and normal salts, which (except those of the alkali metals) are only sparingly soluble or insoluble in water, e.g. $CaC_2O_4.H_2O$.

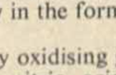
Malonic and Succinic Acids

Malonic acid, the next member of the di-carboxylic acids, formula:



$$CH_2\begin{matrix}\diagup COOH\\ \diagdown COOH.\end{matrix}$$

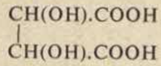
has already been mentioned as an oxidation product of hydracrylic acid. The third member is succinic acid,



$$\begin{matrix}CH_2.COOH\\ |\\ CH_2.COOH\end{matrix}$$

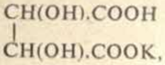
which occurs in amber, in many plants and certain animal secretions. It is also formed in alcoholic fermentation of sugar and in oxidation of fats with nitric acid.

Just as it is possible to form hydroxy-monocarboxylic acids, so by replacing the hydrogen atoms of the CH_2 groups with hydroxyls it is possible to obtain hydroxy-dicarboxylic acids. The most important of these acids is tartaric acid or dihydroxy-succinic acid



$$\begin{array}{l}CH(OH).COOH \\ | \\ CH(OH).COOH\end{array}$$

which occurs in many vegetable and fruit juices, in particular the juice of grapes and the berries of the mountain ash. It is obtained from argol or tartar, which is deposited in wine vats during the later stages of the fermentation of the grapes. Tartaric acid may be prepared in the laboratory from dichloro-succinic acid ; it is a white, crystalline solid, which melts at 167° C. and, like other dicarboxylic acids, forms both normal and hydrogen salts. Of these the potassium hydrogen salt,



$$\begin{array}{l}CH(OH).COOH \\ | \\ CH(OH).COOK,\end{array}$$

also called cream of tartar, is interesting as it is one of the few insoluble potassium salts, and is used as a means of detecting potassium in qualitative analysis. When potassium hydrogen tartrate is heated with antimonous acid and water, potassium antimonyl tartrate is formed.

Tartaric acid provides a classic instance of optical isomerism, four distinct modifications of this substance being known.

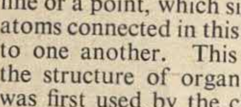
Citric acid is closely allied to tartaric acid. It has the formula $C_6H_8O_7$ and, like tartaric acid, occurs in the free state in many fruit juices. It is a hydroxy-tricarboxylic acid and, like phosphoric acid, forms three classes of salts. Both tartaric and citric acids are used in preparing effervescent salts.

LESSON 33

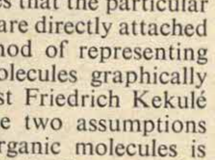
Atom Grouping in Organic Molecules

The use of graphic or structural formulae has already been emphasised. In such formulae each valency is represented by a single line or a point, which signifies that the particular atoms connected in this way are directly attached to one another. This method of representing the structure of organic molecules graphically was first used by the chemist Friedrich Kekulé (1829–96). It embodied the two assumptions that the carbon atom in organic molecules is always tetravalent and that it links up with other carbon atoms to form a chain, the links of which may be a single valency bond (C—C), a double (C=C), or a triple bond (C≡C).

Applying these principles to the paraffin or open-chain hydrocarbons, in the case of each of the first three members, CH_4, C_2H_6, and C_3H_8, there is only one possible way of writing the formula of the molecule. Kekulé's theory therefore agrees with the experimental fact that only one form of each of these three substances is known. However, with butane two distinct isomeric compounds exist, having the constitution C_4H_{10}, which agrees with Kekulé's theory as follows :



normal butane
(b.pt. 0·5° C.)

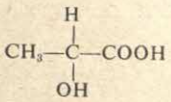


iso-butane
(b.pt. – 10·5° C.)

With pentane three formulae are possible and three isomers are known ; as the number of carbon atoms in the molecule increases, the number of isomers also becomes larger, as many as 802 being theoretically possible in the case of $C_{13}H_{28}$. This form of isomerism is known as *structural isomerism*, since it is concerned with substances which have the same molecular formula but different structural formulae. In general, any of the higher members of a homologous series of open-chain carbon compounds may exhibit this character of structural isomerism.

Stereo Isomers

It has been mentioned that two distinct isomeric forms of lactic acid are known, which are almost identical chemically and differ only in their optical activity. Since both of these acids have the same structural formula :



$$\begin{array}{c}H \\ | \\ CH_3—C—COOH \\ | \\ OH\end{array}$$

the existence of isomerism could not be accounted for by means of the Kekulé theory. It was instances of this kind which suggested that the two-dimensional formulae of Kekulé did not give a true picture of the configuration of molecules, and led to the development of the theory of *stereo*, or *spatial, isomerism* ; stereo-isomers are defined as substances which have the same molecular formula but differ in their molecular configurations in a manner which can best be explained to the student by examples.

The best example of this type is furnished by tartaric acid ; in fact, it was to the classical investigations of the French chemist Louis Pasteur into the nature of this acid that the discovery of stereo-isomerism was chiefly due. Four distinct forms of tartaric acid, each having the constitutional formula $C_4H_6O_6$, are known. The acid obtained from grape-juice is optically active; it rotates the plane of polarised light towards the right—in other words, is *dextro-rotatory*. When the mother-liquor left over after the extraction of this acid is crystallised, a second acid is obtained which has the same chemical properties and therefore the same structural formula as tartaric acid; it differs, however, in some physical properties, and in particular it is *optically inactive*—it is known as *racemic acid*. Sodium ammonium salts of these two acids can be readily prepared in the laboratory, and when dissolved in water they show similar differences in optical properties from those of the acids themselves.

It was while examining these properties that Pasteur discovered in 1848 that the two salts also differed in crystalline form. Thus while all perfect crystals of the salt obtained from *d*-tartaric acid when examined under the microscope had a configuration like that of *d*, in Fig. 32, the crystals of the salt from racemic acid were of two kinds, one of which was identical with the *d* form, and the other had the form shown as *l* in the figure; the two forms were, in fact, related to each other as mirror images, just as the right hand is the mirror image of the left. So distinct were the crystal forms that Pasteur was able to separate them merely by picking out the different shapes, and from these salts he prepared two tartaric acids, one of which was identical with *d*-tartaric acid, and the other was the same in all respects except that it was laevo-rotatory to the same extent as the *d*-acid was dextro-rotatory. It was therefore called *laevo-rotatory* or *l-tartaric acid*.

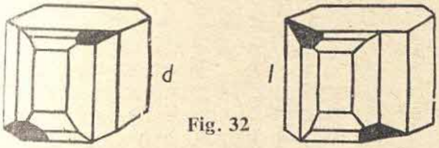
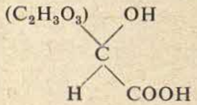


Fig. 32

Pasteur followed up these researches by discovering a fourth isomeric acid, obtained by heating the cinchonine salt of tartaric acid. This form, called *meso-tartaric acid*, resembled racemic acid in being optically inactive, but, unlike the latter, when converted into the sodium ammonium salt it gave crystals of one form only.

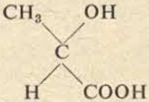
Asymmetric Carbon Atoms

The explanation of these phenomena was advanced simultaneously in 1874 by the French chemist Jules Le Bel (1847–1930) and the Dutch chemist Jacobus Henricus van't Hoff (1852–1911). They pointed out that while the molecules of optically inactive substances, such as ethyl alcohol, acetic acid, and so on, possessed a plane of symmetry, substances which showed optical activity had no such symmetry within the molecule; that is, their molecules are asymmetric. For example, in the case of tartaric acid, represented in the Kekulé fashion:

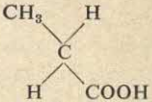


the carbon atom in the centre, to which four different groups are attached, has no plane of symmetry; such a carbon atom is therefore termed an *asymmetric carbon atom*, and it is now known that all optically active molecules possess an asymmetric atom.

If the asymmetry of the molecule is destroyed, it loses its optical activity; for example, when optically active sarco-lactic acid is reduced with hydrogen iodide, it forms optically inactive propionic acid, as might be expected from a consideration of the formulae of these two compounds, viz.,



sarco-lactic acid



propionic acid.

Theory of Tetrahedral Carbon Atom

As a result of Pasteur's work and the discovery of optical isomers, it became obvious that organic molecules could not be truly represented in one plane as Kekulé had suggested, but that they were spatially distributed in three dimensions. This led Le Bel and van't Hoff to put forward their theory of the *tetrahedral carbon atom*, that is, that the carbon atom is, as it were, situated at the centre of a tetrahedron and that the four valencies are directed towards the corners (Fig. 33). When the four solid angles of the tetrahedron are occupied by different atoms, as, for example, in lactic acid, we have the asymmetrical carbon atom, and two distinct forms are then possible. One of these corresponds to the right hand, and rotates the plane of polarised light to the right; the other is the mirror image, or left hand, and rotates the plane to an equal extent to the left. The differences between the four tartaric acids

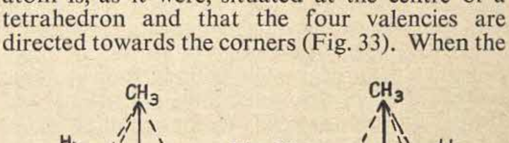
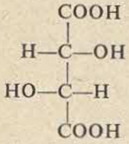
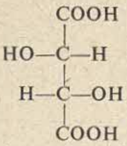
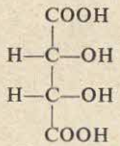


Fig. 33

can be readily explained on this basis, thus (Kekulé's plane formulae are used for simplicity):


d-tartaric acid


l-tartaric acid


meso-tartaric acid

Racemic acid consists of a mixture of equal amounts of the *d*- and *l*- acids, and is therefore inactive ; meso-tartaric acid is inactive for a different reason. It will be seen from the formulae that the upper half of the molecule of meso-acid has the same configuration as the upper half of the molecule of *d*- acid, while the lower half corresponds with the lower half of the *l*- molecule. As might be expected, therefore, the optical activities of the two asymmetric carbon atoms in the meso-acid are equal and opposite ; the molecule is said to be internally compensated.

Trihydric Alcohols

Just as paraffins containing two or more carbon atoms can be converted into dihydric alcohols, so those containing three or more carbon atoms may be converted into alcohols having three hydroxyl groups. Of these trihydric alcohols, *glycerol*, sometimes called glycerin, $CH_2(OH)CH(OH)CH_2(OH)$, is the simplest and the most important. Its preparation from fats and oils as a by-product in the manufacture of soap was mentioned in Lesson 31 ; the "spent lye" from the soap is filtered and evaporated, the product cleansed by filtration through animal charcoal, and the glycerol finally purified by distillation in superheated steam.

Glycerol is a colourless, syrupy liquid with a sweet taste ; it is very hygroscopic and dissolves readily in water and alcohol. Since it contains three hydroxyl groups, it forms three kinds of esters, called mono-, di-, and triglycerides. The triglycerides of the higher fatty and some related unsaturated acids, such as oleic acid, form the main constituents of animal fats and vegetable oils.

When added to a well-cooled mixture of concentrated nitric and sulphuric acids glycerol is converted into glyceryl trinitrate, $C_3H_5(ONO_2)_3$, known technically as *nitro-glycerin*. The formation of this compound is merely a process of esterification, the water being removed as it is formed by the sulphuric acid. Nitro-glycerin is a colourless, oil-like liquid with a sweet, burning taste ; it causes dilation of the blood-vessels, and is used medicinally. When subjected to detonation of any kind it explodes with terrific force. When mixed with *kieselguhr*, a diatomaceous earth, it is absorbed in large quantities, and was used in this form by Alfred Bernhard Nobel (1833–96), the Swedish inventor of dynamite.

Glycerol is fairly readily oxidised and, like glycol, gives rise to a great number of products, according to the manner in which it is treated. Of these the most important is glyceric acid, $CH_2(OH)CH(OH)COOH$, which resembles glycollic acid and is obtained when glycerol is oxidised with dilute nitric acid.

LESSON 34

The Carbohydrates

THIS large group of substances, having the general molecular formula $C_x,(H_2O)_y$, is one of the most important in organic chemistry. Besides being the principal components of all plant and animal foods, carbohydrates are of economic and industrial value, furnishing raw material for the manufacture of alcohol, paper, and vegetable textiles. Carbohydrates may be divided into two large classes—the sugars, which are crystalline, sweet to the taste and soluble in water ; and the non-sugars, which are without crystalline form and amorphous, tasteless, and in general insoluble. In the latter class are included the starches and the celluloses.

There are two well-defined basic units common to all carbohydrates. The first is a five-membered carbon ring resembling a substance called furan ; this gives rise to the so-called furanose forms of sugars. A six-membered ring resembling pyran gives the pyranose forms. If only one ring is present in the structure of the carbohydrate it is called a *monosaccharide* and these are divided into pentoses, containing five carbon atoms, e.g. ribose, and hexoses, with six carbon atoms, e.g. glucose. When two rings are present linked by an oxygen molecule, the carbohydrate is called a *disaccharide*, e.g. sucrose (cane sugar). The third group, containing many rings, is called a *polysaccharide*, and it includes many substances, such as starch and cellulose.

The Monosaccharides

The chemical properties of the monosaccharides indicate that some contain an aldehyde group and are therefore aldehydro-alcohols, sometimes called aldehydic sugars or aldoses ; others contain a ketonic group, $>C=O$, and are keto-alcohols or ketoses. The pentoses give rise to aldehydes, whilst some hexoses give aldehydes and others ketones.

Natural sugars are always optically active and, with one or two exceptions, are dextro-rotatory. The existence of a number of optical isomers in each case might be anticipated, as the formulae shows that the molecules contain several asymmetric carbon atoms. In fact, the large diversity of the sugars is partly due to this property of stereo-isomerism.

Glucose

The very important sugar, *glucose*, occurs in various fruits, particularly in the grape, from which it derives its name of grape-sugar. It is also produced in the blood in large quantities in the disease known as diabetes, and in this case it is formed from various carbohydrates of the diet and sometimes from proteins. Glucose is prepared—together with another hexose, called *fructose*—when cane-sugar (*sucrose*) is decomposed under the action of a dilute acid or certain enzymes. Glucose is dextro-rotatory—hence the name *dextrose* ; in fact, the concentration of a solution can be estimated by measuring the angle of rotation produced by a column of known length. The apparatus used is a *polarimeter* or specifically a *saccharimeter*.

Being an aldehyde, glucose is a strong reducing agent, and when added to alkaline solutions of cupric salts causes a red deposit of cuprous oxide—Cu_2O—to form. The reagent generally used is Fehling's solution, made up by mixing sodium or potassium hydroxide with copper sulphate solution.

Mannose and Galactose

Isomeric with glucose are mannose and galactose, the latter of which is formed, together with glucose, by the hydrolysis of lactose or milk-sugar. Both of these sugars are dextro-rotatory and, like glucose, readily ferment with yeast, producing ethyl alcohol and carbon dioxide (*see* Lesson 30).

Fructose

Fructose, also called *laevulose*, occurs with glucose in sweet fruits and honey. It is readily prepared by the hydrolysis, or inversion, of cane-sugar and the addition of lime, which forms a sparingly soluble compound with fructose, while that formed with glucose dissolves readily. Fructose is laevo-rotatory——hence the name laevulose—and ferments with yeast, though less readily than glucose. It also reduces Fehling's solution to an equal extent, though more rapidly than glucose.

Much brilliant work was done on the synthesis of glucose and fructose by the German chemist Emil Fischer (1852–1919). Starting with formaldehyde CH_2O, which on treatment with milk of lime polymerises to a sugar-like substance having the formula $C_6H_{12}O_6$ and known as formose, Fischer obtained another sugar, and succeeded in converting this into both glucose and fructose.

The Disaccharides

The three most important disaccharides are cane-sugar (*sucrose*), milk-sugar (*lactose*), and malt-sugar (*maltose*). Cane-sugar occurs in large quantities in the ripe sugar-cane and in sugar beet, and in smaller amounts in sweet fruits. In the extraction of sugar the canes are first crushed in a hydraulic press, the juice is then heated with milk of lime to remove the acids present, and the excess of lime is precipitated by passing carbon dioxide into the liquid. The extract is filtered through animal charcoal, concentrated by evaporation in vacuo, and the crystals which form are separated from the syrupy mother-liquor (molasses) by means of centrifugal machines. In the extraction from beet the root is cut into slices and the sugar extracted with water at about 80° C. by a diffusion process ; the extract is then treated as in the case of cane-sugar. The yellow or brown sugars made from cane or beet juice are known as raw sugar ; the latter is refined by dissolving in water and filtering through animal charcoal.

Inversion of Cane Sugar

Aqueous solutions of sucrose are dextro-rotatory, but when warmed with dilute acids or when subjected to the influence of the invertase ferment of yeast, it hydrolyses, giving equal quantities of glucose and fructose. Since fructose is laevo-rotatory to a greater extent than glucose is dextro-rotatory, the resulting solution is laevo-rotatory, and this process of hydrolysis is therefore usually referred to as the inversion of cane-sugar. Chemically, sucrose is a non-reducing sugar —that is, it does not reduce Fehling's solution.

Sucrose is of even greater importance as a food than starch, and the Western peoples consume annually an amount of sugar almost equal to their own weight. Like fats, carbohydrates are necessary sources of energy, but are consumed much more rapidly by the animal organism and give rise to considerably less heat.

Polysaccharides—Starch and Cellulose

The third class of carbohydrates are highly complex bodies, having the general formula $[C_6H_{10}O_5]_n$ where *n* represents a rather large number. Since these compounds appear to be formed by the combination of a number of molecules of mono- or disaccharides with the loss of water, they are usually grouped together under the name *polysaccharides*.

Starch is one of the most abundant products of plant life ; it occurs in large quantities in all kinds of grain, as, for example, wheat, barley, maize, and rice, and also in potatoes, arrowroot, sago, and tapioca. It forms a very important plant food, and under the influence of enzymes is converted into the simpler soluble sugars or the more complex gums and celluloses. When viewed under the microscope it appears to be made up of striated granules, which have a definite size and shape depending on the source from which the starch is obtained. Starch is used commercially chiefly for stiffening linen, and as an adhesive, and in the production of alcohol. It is obtained in quantities by digesting potatoes, maize, or rice with water and removing the suspended starch mechanically. It is insoluble in cold water, but in boiling water the granules burst, forming an opalescent solution which sets to paste on cooling.

Cellulose in the form of cotton or wood pulp forms the basis of artificial silk. The general method of production is to dissolve the cellulose in some suitable solvent or convert it into some soluble form, such as cellulose nitrate, xanthate, or acetate, and then to force the solution through fine capillary orifices into some substance which re-precipitates the cellulose or cellulose derivative. The silk is thus obtained in the form of very fine filaments, which compose the thread woven into fabrics. Artificial silk (or rayon) is therefore not silk at all, being entirely different from natural silk, which is a protein material containing nitrogen.

LESSON 35

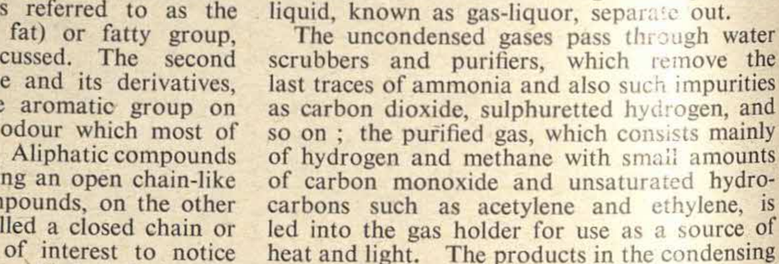
Benzene and its Derivatives

ORGANIC compounds may be classed into two large divisions, which are distinguished by fundamental structural differences. The first of these, which includes the paraffins, the olefines, and the acetylenes and their derivatives, and is referred to as the aliphatic (Gk. *aleiphar*, fat) or fatty group, has already been discussed. The second division includes benzene and its derivatives, and it is known as the aromatic group on account of the peculiar odour which most of these substances possess. Aliphatic compounds are characterised by having an open chain-like structure ; aromatic compounds, on the other hand, contain what is called a closed chain or benzene nucleus. It is of interest to notice that the aliphatic group which includes the fats, carbohydrates, and proteins, is of much greater biochemical significance than the aromatic group. The latter came into prominence as a result of the discovery of the first coal-tar dye by the English chemist Sir William Henry Perkin (1838–1907), in 1856, and the importance of coal-tar products is mainly scientific and industrial, as in the manufacture of dyes, perfumes, explosives, antiseptics, and illuminants.

Benzene derivatives are constituents of many essential oils and of some petroleums, but the most important source of these substances is the tar obtained during the production of coal gas by the destructive distillation of coal. In the manufacture of gas, coal is heated to a temperature of about 1,000° C. in an air-tight iron or clay retort. The more volatile products are driven off and first passed through air condensers, where a considerable quantity of coal-tar and also a strong-smelling yellow liquid, known as gas-liquor, separate out.

The uncondensed gases pass through water scrubbers and purifiers, which remove the last traces of ammonia and also such impurities as carbon dioxide, sulphuretted hydrogen, and so on ; the purified gas, which consists mainly of hydrogen and methane with small amounts of carbon monoxide and unsaturated hydrocarbons such as acetylene and ethylene, is led into the gas holder for use as a source of heat and light. The products in the condensing tanks separate into two layers, the lower of which is the thick, black, oily liquid known as *tar* ; the upper is the gas-liquor, from which most of the ammonia and ammonium salts of commerce are obtained (Fig. 34). The solid residue left behind in the retorts is *coke*, and this amounts to about 70 per cent. of the coal.

Coal-tar contains about 300 substances. The constituents of the tar are first separated



COAL DISTILLATION PLANT. Fig. 34. Diagram showing arrangement of apparatus for production of gas and by-products from coal. Coal coked in retorts gives off tar, collected in a well, and gases. The latter are purified and led into the gas holder.

by fractional distillation, the vapours being condensed over comparatively short ranges of temperature in long iron or lead worms immersed in water. The distillate is collected in fractions, the composition of which is given in the table. The light oil is further purified and then separated into its constituent substances by refractionation. This yields pure and commercial benzene (b.pt. 80° C.), toluene (b.pt. 110° C.), xylene (b.pt. 138°–142° C.), and also some crude higher boiling compounds known commercially as solvent naphtha. The middle oil is centrifuged to remove the crystalline naphthalene which separates out, and the mother-liquor, after suitable treatment, yields pure phenols and also cresols. The heavy creosote oils are used without further treatment as fuels and as a timber preservative. The anthracene oil is allowed to crystallise, and the crystals are removed, warmed, and pressed.

Fractional Distillation of Coal-Tar

Fraction	*Temperature*	*Constituents*
1. Light or crude naphtha	up to 170°C.	Benzene, toluene, xylenes.
2. Middle oil or carbolic oil	,, ,, 230°C.	Phenols, naphthalene and cresols.
3. Heavy oil or creosote oil	,, ,, 270°C.	Cresols, etc.
4. Anthracene oil or green oil	,, ,, 400°C.	Anthracene.
5. Pitch	residue	

The more or less elementary substances given in col. 3 of the table are called "primaries"; they are the source of hundreds of secondary products, known as "intermediates," which are obtained by various chemical processes such as nitration, sulphonation, oxidation, reduction, and so on. Thus, to mention a few typical products, benzene yields nitro-benzene, from which aniline and many azo dyes are made; toluene yields nitro-toluenes, benzaldehyde, benzoic acid, etc.; phenol yields nitro-phenol; naphthalene yields naphthols; anthracene yields anthraquinone, parent substance of many dyes.

Benzene and its Derivatives

Benzene, which has the constitutional formula C_6H_6, is the first member of a homologous series of which the next two members are toluene and xylene. Almost the whole of the benzene of commerce—known as *benzol*—is obtained from coal-tar, though small amounts are present in some petroleums and in the tar obtained from the destructive distillation of wood. Coal-tar benzene, even after careful purification, contains traces of a sulphur compound called thiophene, C_4H_4S, which resembles benzene so closely in physical and chemical properties that it is a matter of some difficulty to separate them. Thiophene, however, reacts with concentrated sulphuric acid and can be removed by shaking the benzene with this reagent.

Benzene has been synthesised by the polymerisation of acetylene in red-hot tubes ($3C_2H_2 \rightarrow C_6H_6$) and is prepared in the pure state by heating sodium or calcium benzoate with soda-lime (compare the production of methane from sodium acetate). Benzene is a colourless, mobile liquid with a characteristic sweetish smell; it burns with a luminous smoky flame, boils at 80·4° C., does not mix with water, but mixes readily with organic liquids, and as it dissolves fats, resins, rubber, etc., it is used as a solvent, and also for cleansing.

Chemically, benzene is a very stable compound; it is not affected by boiling with concentrated alkalis, and is decomposed only very slowly by such strong oxidising agents as potassium permanganate or chromic acid (contrast acetylene). Under certain conditions, however, it reacts with nitric acid to form nitrobenzene, with sulphuric acid to form benzene sulphonic acid, and, in the absence of light, with the halogens, a reaction greatly accelerated by the presence of iodine or iron. In each of these cases the resulting compound is a *substitution product*, not an addition product, which at first sight is curious in view of the apparently unsaturated nature of the benzene molecule, viz. C_6H_6. It was this peculiar stability of benzene, as well as some other reactions—such as its formation from acetylene by a sort of molecular condensation—and also the fact that, when vigorously oxidised, it is decomposed into carbon dioxide and water and yields no intermediate compounds, that led the French chemist Kekulé to put forward the theory of the benzene ring. According to Kekulé, the six carbon atoms are united to one another in the form of a closed ring, on the outside of which, so to speak, are attached the six hydrogen atoms, one to each carbon atom. Since the carbon atoms are distributed symmetrically, they form a hexagon-like structure as shown in the diagrams (Figs. 35*a*, *b*, *c*, and *d*).

It will be noticed, however, that in Fig. 35*a* the carbon atoms are only trivalent, and as

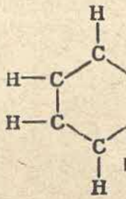


Fig. 35a

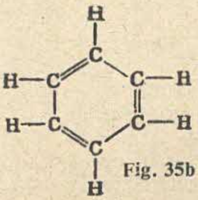


Fig. 35b

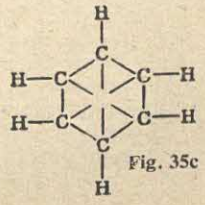


Fig. 35c

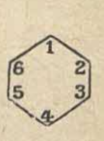


Fig. 35d

carbon is assumed to be tetravalent in all its organic compounds Kekulé introduced alternate double bonds into the ring as shown in Fig. 35*b*. Because of the great stability of the benzene nucleus as compared with unsaturated double-bonded hydrocarbons, objections were later raised to this formula and the "centric formula," Fig. 35*c*, in which the spare carbon valencies are directed towards the centre of the ring, was suggested as an alternative. It is believed now that none of these formulae completely represents the structure of benzene, but that it is a complex affair in which all play some part.

Nomenclature of Benzene Compounds

In the abbreviated formula the hydrogen atoms are omitted, and the presence of an atom or group at one of the corners of the hexagon indicates that the hydrogen atom at this particular point has been replaced by the atom or group shown. Each of the six hydrogen atoms may be replaced in this way by a substituting atom or group—sometimes called a "substituent"—as, for example, in compounds like di-nitrobenzene, $C_6H_4(NO_2)_2$, tetrachlorbenzene, $C_6H_2Cl_4$, hexa-carboxybenzene, $C_6(COOH)_6$, and so on. When one substituent group has been introduced, the resulting compound obviously exists in one form only, since the benzene ring is symmetrical.

The introduction of a second substituent, however, can take place in three different positions in the molecule. There are, therefore, three isomeric di-substituted compounds. To facilitate matters of nomenclature the carbon atoms in the ring are numbered in a clockwise direction as shown in Fig. 35*d* ; the three isomeric di-nitrobenzenes are then written graphically ; they are also distinguished by the prefixes ortho-, meta-, and para- (more shortly o-, m-, and p-), according as the substituents are in the 1 : 2, the 1 : 3, or the 1 : 4 positions, as seen in Fig. 36. Substitution in the para-position leads to a symmetrical molecule.

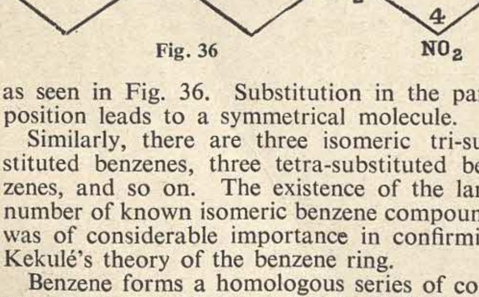


Fig. 36

Similarly, there are three isomeric tri-substituted benzenes, three tetra-substituted benzenes, and so on. The existence of the large number of known isomeric benzene compounds was of considerable importance in confirming Kekulé's theory of the benzene ring.

Benzene forms a homologous series of compounds having the general formula C_nH_{2n-6}, the higher members of which are obtained when the hydrogen atoms of benzene are replaced by alkyl groups. The second member, methyl-benzene or toluene, $C_6H_5.CH_3$, exists in one form only ; but the next, having the molecular formula C_8H_{10}, occurs in four isomeric forms—ethylbenzene, $C_6H_5.C_2H_5$, and the three dimethylbenzenes, usually called the xylenes, having the formula $C_6H_4(CH_3)_2$. It is obvious that the number of possible isomers increases rapidly with the number of carbon atoms.

Preparation of Benzene Homologues

Two general methods are used for the preparation of these compounds and are of considerable importance. In the first, known as *Friedel and Crafts' reaction*, benzene or one of its homologues is treated with an alkyl halide in the presence of anhydrous aluminium chloride ; the reaction in the case of the preparation of toluene may be written :

$$\underset{\text{benzene}}{C_6H_5.H} + \underset{\substack{\text{methyl}\\\text{chloride}}}{Cl.CH_3} \rightarrow \underset{\text{toluene}}{C_6H_5.CH_3} + HCl.$$

By using a large excess of methyl chloride it is also possible to prepare the di- and tri-methylbenzenes. The second method, discovered by the German Rudolf Fittig (1835–1910) and known as *Fittig's reaction*, consists in heating a halogen derivative of the aromatic hydrocarbon with an alkyl halide and sodium metal, thus :

$$C_6H_5.Br + 2Na + I.CH_3 \rightarrow NaI + NaBr + C_6H_5.CH_3.$$

Like benzene itself, these homologues are all comparatively stable, but yield nitro and sulphonic derivatives ; on treatment with strong oxidising agents the attached alkyl groups—known as side chains—are oxidised, being ultimately converted into carboxyl groups.

Nomenclature of Homologues

The nomenclature of benzene derivatives has been systematised by the adoption of the names *phenyl* for the benzene radical, C_6H_5—, sometimes written Ph ; *phenylene* for the $C_6H_4<$ radical ; benzyl for the toluene radical, $C_6H_5CH_2$—, and so on.

Nitro-Compounds of Benzene

When an aromatic hydrocarbon is treated with a mixture of concentrated nitric acid (12 parts) and sulphuric acid (16 parts) at ordinary temperature, a process called nitration takes place, one hydrogen atom being replaced by a nitro (NO_2) group giving a mono-nitro compound. Thus benzene yields nitrobenzene according to the equation :

$$C_6H_6 + HNO_3 \rightarrow C_6H_5.NO_2 + H_2O.$$

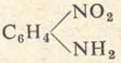
If the acid mixture is present in large excess and the liquid heated, di- and tri-nitro compounds are formed ; in the case of benzene, the principal product is metadinitrobenzene. These aromatic nitro compounds are generally relatively insoluble in water, but dissolve readily in organic solvents such as benzene, ether, etc. Like the nitro-paraffins, they are fairly stable, being unaffected by boiling caustic potash.

Nitrobenzene

Nitrobenzene is perhaps the most important of this class of compounds, since on reduction it yields aniline, the source from which the aniline dyes are prepared. Nitrobenzene is a pale yellow oil, slightly heavier than water, and having an odour which resembles bitter almonds. Although the vapour is a fairly active poison it is used under the name of oil of mirbane as a cheap perfume and as flavouring essence.

Amino-Benzene (Aniline)

When treated with a reducing agent in acid solution, as, for example, hydrogen produced by the action of hydrochloric acid on tin, zinc, or iron, or—which is more usual—a solution of stannous chloride in hydrochloric acid, the nitro group is reduced to the amino group (NH)$_2$, giving amino-benzene, a substance usually known as *anilene* (from *an-nil* the Arabic word for indigo). In practice the aniline is obtained combined with the acid in the form of a complex salt ; it is liberated by the addition of lime or caustic soda, and is separated by distillation in a current of steam or extraction with ether. This method of reducing aromatic nitro compounds to the corresponding amino compounds can be applied to practically all types ; in the case of di-nitro compounds it is possible, by stopping the reaction at the prescribed point, to reduce only one nitro group, the resulting product being called a nitraniline, e.g.



$$C_6H_4\begin{matrix}NO_2\\NH_2\end{matrix}$$

Properties of Aniline

Aniline is a colourless oil of peculiar odour, which, together with analogous substances, yields the dyes of the rosaniline group, including magenta, fuchsine, and others. Structurally, it is a primary amine and may be regarded as an ammonia molecule, in which one hydrogen atom has been replaced by the phenyl group. As might be expected, therefore, it retains some of the basic properties of ammonia ; and although neutral to litmus, it reacts fairly readily with acids to form salts such as aniline hydrochloride $C_6H_2.NH_6.HCl$, and with acetylchloride to form a substance known as acetanilide, $C_6H_5.NH.CO.CH_3$, which is a flaky white, crystalline solid.

Other members of the benzene series also form primary amines, which are analogous to aniline and have similar chemical properties. The toluene compounds, or toluidines, of which there are three having the constitutional formula $CH_3.C_6H_5.NH_2$, are used in the production of dyes.

The diazonium reaction, discovered in 1858 by Peter Griess (1829–88), is probably the most important of the reactions of the aromatic amino compounds. It takes place whenever a primary amine, such as aniline or toluidine, having the NH_2 group attached directly to the nucleus, is treated with well-cooled nitrous acid ; a mixture of sodium nitrite and sulphuric acid is generally used.

Diazo Salts

In the case of aniline, the following reaction takes place :

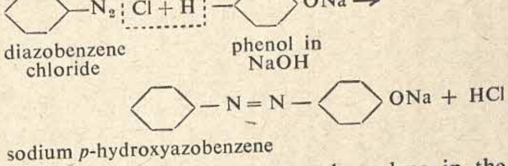
$$C_6H_5.NH_2+O.NOH+HCl \rightarrow \underset{\text{phenyl diazonium chloride}}{C_6H_5.N_2.Cl}+2H_2O$$

Phenyl diazonium chloride is a typical diazo salt ; these compounds are colourless crystalline solids readily soluble in water. In the dry state they are explosively reactive and are therefore not isolated from their aqueous solutions.

When heated, these solutions yield phenols, as, for example, C_6H_5OH ; with concentrated halogen acids they give halogen derivatives such as C_6H_5I ; on treatment with a solution of a cuprous salt, such as cuprous chloride, in the presence of hydrochloric acid or cuprous cyanide in potassium cyanide solution, the diazonium group may be replaced by Cl, (CN), Br, I, and indirectly by COOH and other groups. This latter reaction is known as *Sandmeyer's reaction*, and is a valuable means of preparing derivatives of the aromatic hydrocarbons.

Azo Dyes

Perhaps the most important reaction of diazo salts is the so-called coupling reaction which is the basic of the production of the intensely coloured orange or red azo dyes. This reaction takes place with the separation of hydrochloric acid when a diazonium compound is added to a solution of a phenol in dilute caustic alkali or to tertiary aromatic amines dissolved in dilute acid :



sodium *p*-hydroxyazobenzene

In general, the coupling takes place in the para position, and the bright colours of the resulting azo compounds are attributed to the grouping —N—N—, which is known as the *azo chromophore.* Chromophore is the name given to the group of atoms in the molecule to which the colour is considered to be due.

When benzene is heated with concentrated sulphuric acid, it dissolves slowly, forming benzene-sulphonic acid, according to equation :

$$C_6H_5 \,\vdots\, H + HO \,\vdots\, SO_3H \rightarrow C_6H_5 . SO_3 . H + H_2O.$$

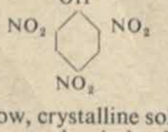
This reaction illustrates an important difference between aromatic and aliphatic hydrocarbons. The sulphonic acids are comparatively stable crystalline compounds which have many of the properties of strong acids. Under the right conditions they can be fairly readily converted into other compounds, and so are of some importance in synthetic chemistry. For example, when fused with caustic potash they yield phenols ; when heated with potassium cyanide they are converted into cyanides ; with phosphorus pentachloride they give acid chlorides ; with concentrated ammonia, amides, such as benzene sulphonamide, $C_6H_5 . SO_2 . NH_2$.

The hydroxy compounds of the aromatic hydrocarbons, which correspond to the aliphatic alcohols, may be divided into two classes: the phenols, in which the hydroxyl groups have displaced hydrogen atoms of the benzene nucleus, and the aromatic alcohols, in which the hydroxyl group is attached to a side chain. An example of the first class is phenol itself, also called hydroxy-benzene, C_6H_5OH ; of the second, benzyl alcohol, $C_6H_5 . CH_2OH$. Like the aliphatic alcohols, the phenols may be divided into monohydric, dihydric, trihydric, and so on, according as they have one, two, three, or more hydroxyls combined directly with the carbon of the nucleus. In general, the phenols have weakly acidic properties reacting with sodium hydroxide to form phenates ; like the alcohols, they react with phosphorus pentahalides and also give rise to esters and ethers.

LESSON 36

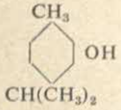
Carbolic Acid and its Derivatives

In the preceding Lesson it was mentioned that the hydroxy compounds of the aromatic hydrocarbons are of two types, the phenols and the aromatic alcohols. The simplest member of the first class is ordinary *phenol*, also called *carbolic acid*, C_6H_5OH ; it is obtained in quantities from the middle oil extracted from coal-tar, also by the hydrolysis of salts of diazo-benzene, or by fusing benzene-sulphonic acid or its salts with caustic potash. When pure, phenol is a colourless crystalline solid which absorbs water readily and turns pink on exposure to the air. It acts as a protoplasmic poison, and is used as a disinfectant, germicide, and antiseptic. When treated with dilute nitric acid, it yields a mixture of ortho (*o*-) and *p*-nitrophenol, but with a hot nitrating mixture (concentrated nitric and sulphuric acids) three nitro groups are introduced into the molecule, the product being 2 : 4 : 6 trintrophenol, or picric acid. This has the formula:

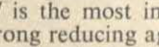


It is a bright yellow, crystalline solid and was the first artificial dye used ; it is also used as an explosive, known as lyddite. With an aqueous solution of ferric chloride, phenol produces a deep violet colour, a reaction which is used as a test for the presence of ferric chloride. It also forms the basis of a number of medicinal compounds such as salicylic acid, aspirin, and phenacetin, also of important dyes, as, for example, phenolphthalein.

The next homologue of phenol is hydroxy-toluene, which exists in the three isomeric forms (*o*- *m*- and *p*-) called the *cresols*. These substances occur in coal-tar and can be prepared by the methods available for phenol. Of the higher monohydric phenols, *thymol* is perhaps the most interesting ; it has the odour of oil of thyme, in which it occurs, and is used as an antiseptic ; it has the constitution :

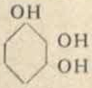


Of the three (*o*- *m*- and *p*-) dihydric phenols, having the formula $C_6H_4(OH)_2$, *quinol* or *hydroxy-quinone* is the most important. It has the structure:



It is a strong reducing agent, and is used as a photographic developer.

Three trihydric phenols are known, of which *pyrogallol* is the most interesting ; like quinol, it is a strong reducing agent, and under the names "pyrogallic acid" or "pyro" was used as a developer in photography. It has the structure:



The aromatic alcohols in which the hydroxyl radical is introduced into a side chain differ from the phenols in showing properties which are identical with those of the aliphatic alcohols. For example, they form esters, ethers, aldehydes, and ketones, usually by reactions similar to those by which the corresponding aliphatic compounds are prepared. They resemble the phenols, however, in reacting with nitric acid to form nitro-compounds, and with sulphuric acid to form sulphonic acids, reactions which are both due to the presence in the molecule of the benzene ring.

Aromatic Alcohols

Benzyl alcohol, the first member of this series, $C_6H_5.CH_2OH$, is prepared by the hydrolysis of benzyl chloride ($C_6H_5.CH_2Cl$) with boiling aqueous sodium carbonate solution, or by treating benzaldehyde with cold caustic potash. Like alcohol, it reacts with metallic sodium to form a sodium alcoholate, and with strong hydrochloric acid or phosphorus pentoxide to form benzyl chloride. On treatment with concentrated nitric acid it is oxidised to benzaldehyde $C_6H_5.CHO$.

The oxidation of an aromatic alcohol such as benzyl alcohol results in the formation of an aldehyde which may be of two types, according as the alcohol (sometimes called carbinol) group, $-CH_2OH$, is attached to a side chain or to the nucleus itself. Compounds of the former type resemble the aliphatic aldehydes very closely and are relatively unimportant, but the second class differ in several respects.

Aromatic Aldehydes

Benzaldehyde is a colourless, refractive liquid with a pleasant smell like that of bitter almonds. It is used as a flavouring essence and in the manufacture of various dyes, and is obtained by the hydrolysis of amygdalin, a glucose present in bitter almonds. Like the aliphatic aldehydes, it may also be prepared by the oxidation of benzyl alcohol or by heating a mixture of calcium benzoate and calcium formate. Benzaldehyde, and, in fact, aromatic aldehydes in general, resemble the fatty aldehydes in readily undergoing oxidation to form the corresponding acid and reduction to the corresponding alcohol. They differ from the fatty compounds in that they do not reduce Fehling's solution and, when shaken with caustic potash, they produce a mixture of the corresponding alcohol and acid, thus :

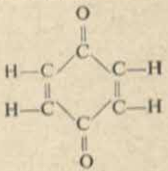
$$2C_6H_5.CHO + KOH \rightarrow C_6H_5.CH_2OH + \underset{\text{potassium benzoate}}{C_6H_5.COOK}$$

Aromatic Ketones

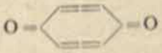
Like the aliphatic ketones, the aromatic ketones have the general formula $R.CO.R_1$, where R and R_1 may be the same or different radicals, one of which is aromatic. *Acetophenone*, $C_6H_5.CO.CH_3$, is a typical ketone and is formed when calcium benzoate is heated with calcium acetate. It is a crystalline solid and is used as a hypnotic in medicine under the name of hypnone. When calcium benzoate is heated alone, *benzophenone* is formed ; it has the formula $C_6H_5.CO.C_6H_5$ and resembles acetophenone very closely.

Di-Ketones (or Quinones)

Aromatic hydrocarbons also yield another class of ketone-like compounds, in which the carbon atom of the ketone ($>C=O$) group is part of the benzene ring. These substances are generally di-ketones and are known as *quinones* ; the commonest quinones have the two carbonyl groups in the para or symmetrical position. *Quinone* itself, sometimes called *p*-benzoquinone, is formed by the oxidation of quinol or when aniline is oxidised with a mixture of sulphuric acid and potassium dichromate. On reduction with sulphurous acid, quinone is converted into quinol ; its molecule is written graphically :



All of these quinones crystallise in brightly coloured plates, which are generally yellow ; the colour is attributed to the presence in the molecule of the quinonoid-chromophore :



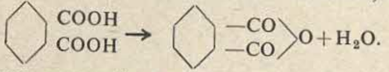
which is the basis of a large number of very important dye-producing compounds.

Aromatic Acids

Two types of aromatic acid also exist, those which contain the carboxyl group ($-COOH$) attached to the benzene nucleus, and those in which it is attached to a side chain. These two types are similar in chemical properties, both forming salts, esters, amides, and so on, in a manner exactly analogous to the fatty acids. In addition to the simple mono-carboxylic acids, di- and poly-carboxylic acids are known, and in most cases one or more hydrogen atoms of the nucleus may be replaced by other atoms or groups, such as $-OH$, $-NO_2$, $-Cl$, alkyl groups, and so on.

The simplest monocarboxylic acid is *benzoic acid*, $C_6H_5.COOH$, which occurs in the free state in gum benzoin, a naturally occurring resin, from which it may be obtained by sublimation. It is also prepared by oxidising toluene or benzyl alcohol. Benzoic acid is a white crystalline solid, which dissolves in water and forms well-defined salts, called benzoates, and also esters. With phosphorus pentachloride, it forms benzoyl chloride, $C_6H_5.CO.Cl$, which reacts with ammonia to form benzamide, $C_6H_5.CO.NH_2$ (compare acetamide). Benzoic acid is a powerful antiseptic and is used as a food preservative for coffee extracts, fruit juices and cordials.

The most important di-carboxylic acids are the three (ortho, meta, and para) *phthalic acids*, which have the formula $C_6H_4(COOH)_2$. They are prepared by oxidising the corresponding xylenes, the ortho-compound being also obtained commercially by the oxidation of naphthalene with fuming sulphuric acid in the presence of a little mercury, which acts as a catalyst. The ortho acid, generally known simply as phthalic acid, is of great industrial importance, as it is the parent substance used in the production of indigotin (which furnishes artificial indigo), fluorescin, eosin, and many other dyes. For this purpose it is usually converted into phthalic anhydride, an "inner" anhydride formed when the acid is distilled, thus:



Some aromatic amino and hydroxy-acids are of importance. *Anthranilic acid* or *o*-amino-benzoic acid, $NH_2.C_6H_4.COOH$, is obtained from phthalic anhydride and is an intermediate product in the preparation of indigotin. *Salicylic acid*, or *o*-hydroxy-benzoic acid, $C_6H_4(OH).COOH$, occurs in considerable quantities in the form of the methyl ester in oil of wintergreen; it is obtained by the oxidation of salicylic alcohol. It is used in medicine, in the manufacture of aspirin, and in the dye industry.

Gallic acid is a trihydroxybenzoic acid (3 : 4 : 5), that is, the hydroxyl groups are attached to the three adjacent carbon atoms in the ring, one place removed from the carbon atom to which the carboxyl group is attached (*see* Lesson 35). It occurs in the free state and also as a glucoside in nut galls, tea, and other vegetable products, and is prepared by hydrolysing tannin with hot dilute acids. Like pyrogallol, gallic acid is a strong reducing agent, because of the ready oxidisability of the hydroxyl groups. With ferric salts, it gives a blue-black precipitate which forms the basis of the manufacture of ink.

Ink consists essentially of a solution of gallic acid and a ferrous salt, together with a little sulphuric acid and a blue dye to give the solution a certain amount of permanent colour. On exposure to the oxygen of the air the ferrous salt is immediately converted into ferric salt, which reacts at once with the gallic acid.

LESSON 37

Dyes and Dyeing Processes

NAPHTHALENE and anthracene both occur in fairly large quantities in coal-tar, and as they give rise to a number of intermediates which are extensively used in the dye industry they are of considerable importance. *Naphthalene*, crystallising in large lustrous flakes which melt at 79° C. and have the characteristic odour of moth-balls, is the most abundant of the coal-tar hydrocarbons. It burns with a smoky, luminous flame, and before the days of electric light was often used to increase the luminosity of coal-gas. Naphthalene has the formula $C_{10}H_8$ and is therefore not a homologue of benzene; however, it shows many of the chemical properties characteristic of the aromatic hydrocarbons, as, for example, a tendency to form nitro compounds with nitric acid and sulphonic acids with sulphuric acid.

Also, when naphthalene is mixed with an alcoholic solution of picric acid, it forms yellow, crystalline, naphthalene picrate.

Like benzene, it is a very stable compound, but when boiled with dilute nitric, chromic, or sulphuric acid it is oxidised fairly rapidly, especially in the presence of mercury, the products being orthophthalic acid, carbon dioxide, and water. This indicates that the molecule of naphthalene contains at least one ortho-di-substituted benzene ring (*see* above), and as a result of other reactions, it was shown to consist of two closed chains of six carbon atoms "condensed" together in the ortho position (*see* Fig. 37.)

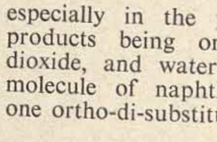


Fig. 37

As in the case of benzene, the above structural formula was confirmed by a study of the isomerism of the various substitution products. It will be seen that there are two possible mono-substitution products (contrast benzene, which gives rise to only one in each case), and in order to simplify matters of nomenclature the carbon atoms in the molecule are either numbered or lettered with the Greek letters alpha and beta, as shown in Fig. 38.

The most important derivatives of naphthalene are the naphthylamines, the sulphonic acids, and the two naphthols; α-naphthylamine is prepared in a similar manner to aniline by the reduction of the nitro compound, which is formed when concentrated nitric acid acts on naphthalene. It has the formula $C_{10}H_7 . NH_2$.

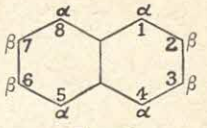


Fig. 38

Sulphonic Acids

When treated with concentrated sulphuric acid, naphthalene is converted into the mono-substituted acids, naphthalene *α-sulphonic acid* at 80° C. and *β-sulphonic acid* at between 160° and 200° C. Several other complex isomeric sulphonic acids may be obtained by the action of sulphuric acid on other naphthalene compounds, such as the naphthylamines; of these probably the most important is the product from α-naphthylamine called *naphthionic acid* and having the formula $C_{10}H_6.(NH_2).SO_3H$. This substance, which may be diazotised in the ordinary way and also coupled with diazo salts (*see* Lesson 35), is used in the production of Congo red and other dyes.

Naphthols

When these sulphonic acids are fused with caustic soda they are converted into the naphthols (α- or β-). This reaction is similar to those by which the phenols are produced; it is written thus:

$$C_{10}H_2 . SO_3Na + NaOH \longrightarrow Na_2SO_3 + \underset{(\alpha\text{- or }\beta\text{-naphthol})}{C_{10}H_7 . OH.}$$

The naphthols resemble the phenols, and since they also couple with diazo salts they are of considerable importance in the dye industry.

Besides these substances, naphthalene is also the main source of *phthalic acid*, a compound which is used in a manner described in the preceding Lesson in making synthetic indigotin, the main constituent of natural indigo dye.

Alizarin

Anthracene has the constitution $C_{14}H_{10}$, and has been shown by methods similar to those applied to naphthalene to consist of three "condensed" benzene rings (Fig. 39); it is a fairly stable, white crystalline solid which melts at 213° C. When oxidised with nitric or chromic acid it is converted into a yellow crystalline compound which has the quinone structure shown in Fig. 41 and is known as *anthraquinone*. This substance, when heated with concentrated sulphuric acid, forms a mono-sulphonic acid, which on fusing with caustic soda and a little potassium chlorate furnishes the important dye known as *alizarin*. Alizarin has the structure shown in Fig. 42; it forms the basis of the Turkey red dye, which formerly was obtained from the madder plant.

Vegetable Alkaloids

Phenanthrene, $C_{14}H_{10}$, is isomeric with anthracene and also occurs in coal-tar. It has the structure shown in Fig. 40, and though it is of theoretical rather than commercial importance it forms the basis of some substances, such as morphine, which belong to the class of compounds known as the vegetable alkaloids.

Synthetic Dye Industry

A century ago all the dyes in use were obtained directly from some natural source, and it was considered impossible for the chemist to manufacture in the laboratory the bright colours which are formed under the influence of life forces in nature. This belief was shaken in 1856 when Sir W. H. Perkin, then a young London student, while engaged in an abortive attempt to prepare quinine from aniline oil made from coal-tar products, prepared a synthetic purple dye known as mauveine or Perkin's mauve. This was the first synthetic aniline dye.

Many thousands of different dyes are now made synthetically. Only a very few of these correspond to natural dyes, with which they are then chemically identical; the great majority do not exist in nature at all.

Chemical Composition of Dyes

Substances which are called dyes, in addition to being coloured, must also be able to "fix" themselves or be fixed to the fabric to be dyed in such a way that they remain reasonably fast to soap and water and also to sunlight. Azobenzene, for example, is intensely coloured, but it is not a dye since it is readily removed by washing. Similarly, when calico or cotton is treated with picric acid the cloth is coloured

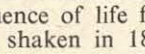


Fig. 39

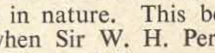


Fig. 40

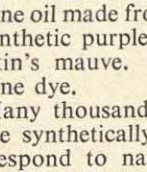


Fig. 41

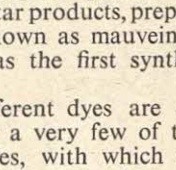


Fig. 42

yellow but the colour dissolves in water, although picric acid is firmly fixed by wool or silk, and may be used to dye these fabrics.

The colour of dyestuffs is attributed to the presence in the molecule of certain groups of atoms called chromophores. The parent substance of any group of coloured compounds which contains the chromophore is usually known as the *chromogene* ; it may or may not be a dye, and if not, it is converted into a dye by the addition to the molecule of certain groups such as $—OH$, $—SO_3H$, $—NH_2$, $—NMe_2$, and so on, which are called *auxochromes*. It will be noticed that these groups are either acidic or basic, and different methods of applying the dye to the fabric must be adopted.

LESSON 38

Chemistry of Plastic Materials

PLASTICS are those materials which flow under the action of heat and/or pressure at some time during their processing, and by popular consent the term excludes such materials as bitumen, glass, and shellac. Plastics can be subdivided into two main groups ; the thermosetting and the thermoplastic materials. The former under heat action undergo a chemical change and become infusible and insoluble and have a cross-linked structure, preventing further relative movement. Thermoplastics, on the other hand, can be softened and resoftened by heat action, since their contiguous chains cannot be anchored relative to one another.

Raw Materials

Both natural and synthetic materials are used. Examples of naturally occurring materials include cellulose, alginates, casein, and other protein-containing materials. Synthetic materials are now more usually used in the manufacture of polymers, e.g. benzene, ethylene, and acetylene. Phenol originally obtained from coal is the basis of phenol/formaldehyde resins and also of nylon. To-day phenol is prepared synthetically from benzene. Formaldehyde, normally handled as a 40 per cent. aqueous solution known as formalin, is prepared from carbon monoxide and hydrogen via menthane. Acetylene can be reacted with hydrochloric acid, acetic acid, etc., to form monomers which can be directly polymerised to form useful plastic materials. Acetylene is also used in the manufacture of solvents and plasticisers. Ethylene can be separated from cracked gases and the chemical breakdown products of coal and petroleum.

Phenolic Resins

Phenolic plastics are based on the condensation of phenols with formaldehyde in the presence of catalysts, the phenols mainly used being phenol itself, cresols, and resorcinol. After the phenol has been condensed with formaldehyde the resin is worked up with fillers to produce the moulding powders. General purpose mouldings normally contain woodflour as filler, but mica is used for electrical purposes, and for shock resistant mouldings cotton flock or chopped nylon are mainly used. Paper and fabric can be impregnated with a phenolic resin solution to produce laminates, which are used for constructional and electrical purposes. These phenolic resins are also used as impregnants, varnishes, and adhesives.

Aminoplastics

These plastics are based on the condensation of urea, thiourea, or melamine with formaldehyde. Aminoplastics are used in the decorative trades in the form of mouldings, adhesives, laminates, and protective finishes. When a water-soluble urea formaldehyde resin is foamed and cured with a catalyst, a heat-insulating material is obtained with a density as low as ½ lb. a cubic foot after the removal of the water.

Alkyd Resins (Glyptals)

The alkyd resins, formerly more often referred to as the glyptals, are prepared by reacting polyhydric alcohols, e.g. glycerols, with polybasic acids, e.g. maleic acid. Their rate of cure is slow and their main use is in the manufacture of synthetic finishes.

Allyl Plastics

These plastics, based on the polymerisation of allyl alcohol in the presence of a catalyst, normally an organic peroxide, are used as organic glasses in view of their excellent transparency and scratch resistance. In contradistinction to the phenolics and ureas, low pressures only are necessary to effect rapid polymerisation of these products, which makes them eminently suitable for the production of laminates in complicated shapes.

Casein

The protein plastics as a class are midway between the thermosetting and thermoplastic types as they can be softened slightly on reheating. The earliest protein used (and still the most important) is casein, which is obtained from the whey of cows' milk. Casein mixed with water and suitable plasticisers is extruded or pressed into sheets, and cured by immersion in a 5 per cent. formalin solution for shorter or longer periods.

Liquid Silicones

The silicones are a comparatively new range of plastics in liquids, solids, or rubbers, which because of the silicon-oxygen bridge in their structure have an excellent temperature resistance compared with the other plastics. The liquids have noteworthy electrical heat resistance and water repellant properties. Liquid silicones have a fairly constant viscosity over wide ranges of temperatures and are useful as lubricants at high temperatures.

Cellulose Nitrate

α-cellulose from purified wood pulp or cotton linters is used in the manufacture of the cellulose plastics. Cellulose nitrate is used in a variety of industries, and its properties and utility mainly depend on its nitrogen content. Cellulose nitrate with a nitrogen content above 13·0 per cent. is more commonly known as gun cotton. When the nitrogen content is between 11·9 and 12·2 per cent. it is used in the film and lacquer industries. Celluloid has a nitrogen content of 10·8 per cent. and is invariably plasticised or softened with camphor. A disadvantage of celluloid is its inflammability, but although it was the first plastic to have been produced commercially it still retains an important position.

Cellulose Acetate

These plastics are manufactured by esterifying cotton linters with a mixture of acetic acid and acetic anhydride in the presence of sulphuric acid as catalyst. The initial product is the triacetate, and it has a combined acetic acid content of 62·5 per cent. Comparatively insoluble in common solvents, it is usually saponified until the combined acetic acid content is between 53·0 and 56·0 per cent., within which range cellulose acetate is generally soluble in acetone.

Ethenoid Plastics

This type of plastic includes polyethylene, polyvinyl materials, and polystyrene. Polyethylene is well known for its very low power factor and chemical inertness, hence its use in electronics.

The most important vinyl polymers are based on vinyl chloride, vinyl acetate, vinyl alcohol, vinylidene chloride, and formvar. Chemical combinations of two or more of these materials are known as co-polymers. Formvar is used as an interlayer in shatterproof glass. Polyvinyl chloride (P.V.C.) and co-polymers of vinyl chloride with vinylidene chloride or vinyl acetate are used for making the so-called plastic sheeting, coatings, chemical resistant plant, lacquers, adhesives, and fibres. Styrene is prepared from benzene via ethyl benzene, and can be polymerised, or co-polymerised with other monomers, to produce a wide range of materials. Polystyrene is used as a plastic for novelty goods, electrical components, foils, and cements.

"Perspex"

Methyl methacrylate polymers, popularly known under the trade name "Perspex," are manufactured from acetone via acetone cyanhydrin. "Perspex" is used for making lenses and other optical equipment. Modern dentures are prepared by heating in a mould a dough consisting of methyl methacrylate monomer, the polymer, and a catalyst.

Manipulation of Thermo-setting Resins

The thermosetting resins in the form of moulding powders are normally pelleted and preheated, usually by high-frequency heating, before moulding. The pellets are then transferred to the hot mould which is heated under pressure. The powder flows, becomes cured, and can be ejected hot from the mould. The temperature, time of pressing, and hydraulic pressure used vary according to the size of moulding and the type of moulding powder.

Manipulation of Thermoplastics

Injection moulding machines are used for fabricating the thermoplastics. The powder is heated in a cylinder and made to flow into a cooled mould ; the mould is split mechanically and the article ejected. By extruding through a die a hot mass of either a thermoplastic or a thermosetting resin regular shapes in continuous lengths are obtained.

Solutions of cellulose acetate and nitrocellulose in volatile solvents such as acetone can be poured or "cast" on a slowly rotating highly polished drum. The solvent is evaporated at an elevated temperature and the deposited film is stripped from the drum. These films are used in the manufacture of photographic film, and in the electrical industry. A solution of cellulose acetate is also used in the manufacture of cellulose acetate rayon by expressing this through a fine orifice into a heated cabinet. Fabrics treated with urea or melamine resin solutions are crease resistant.

Moulding of Partly Cured Plastics

Partially cured phenolic resins in the form of syrups can be poured into moulds, and acid catalysed at low temperatures to give colourful products. Suitable moulds can be cheaply prepared from highly plasticised P.V.C. or lead. Such moulds are usually melted for re-use.

BOOK LIST

General. *Science for the Citizen*, L. Hogben (Allen and Unwin) ; *Chemistry in Modern Life*, S. Arrhenius (Chapman and Hall) ; *General and Inorganic Chemistry*, Durrant (Longman) ; *Everyday Chemistry*, Partington (Macmillan).

Elementary Chemistry (Inorganic). *Outlines of Inorganic Chemistry*, J. Morris (Methuen) ; *Intermediate Chemistry*, Lowry and Cavell (Macmillan) ; *Modern Inorganic Chemistry*, Mellor (Longman) ; *Intermediate Chemistry*, Prescott (University Tutorial Press).

Colloidal Chemistry. *Elements of Colloidal Chemistry*, H. Freundlich (Methuen) ; *Chemistry of Colloids*, V. Poschl (Griffin) ; *Colloid Chemistry*, R. Hartman (Pitman) ; *Introduction to Colloid Chemistry*, H. N. Holmes (Chapman and Hall) ; *Chemical Solutions*, Welcher (Chapman and Hall).

Physical Chemistry. *Physical Chemistry for Schools*, H. J. H. Fenton (Camb. Univ. Press) ; *Physical Chemistry for Colleges*, E. B. Millard (McGraw) ; *Textbook of Physical Chemistry*, S. Glasstone (Macmillan).

Industrial Chemistry. *Industrial Chemistry*, Martin and Cooke (Technical Press).

Catalysis. *Catalysis in Theory and Practice*, Rideal and Taylor (Macmillan) ; *Catalysis and its Industrial Applications*, E. B. Maxted (Churchill).

Organic Chemistry (Carbon Compounds). *Introduction to Carbon Compounds*, R. H. Adie (University Tutorial Press) ; *Outlines of Organic Chemistry*, H. J. H. Fenton (Camb. Univ. Press) ; *Introduction to Organic Chemistry*, J. W. Baker (Dent) ; *Modern Theories of Organic Chemistry*, H. B. Watson (Oxford) ; *Organic Chemistry*, J. Read (Bell) ; *Organic Chemistry*, Schmidt (Gurney and Jackson).

Electrochemistry. *Principles of Electro-Chemistry*, D. A. Macinnes (Chapman and Hall) ; *Principles of Applied Electro-chemistry*, Allmand and Ellingham (Arnold).

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The Atom and Its Structure. *The Atom*, E. N. da C. Andrade (Bell); *Atomic Structure*, L. B. Loch (Chapman and Hall) ; *Modern Atomic Theory*, J. C. Speakman (Arnold) ; *Atomic Energy and its Applications*, Leniham (Pitman) ; *Atomic Energy for the Layman*, Dixon (Chantry Press) ; *Harwell* (H.M.S.O.) ; *Britain's Atomic Factories* (H.M.S.O.) ; *A Programme of Nuclear Power* (H.M.S.O.) ; *Introduction to Atomic Physics*, Tolansky (Longman).

Carbohydrates. *The Carbohydrates*, E. F. and K. F. Armstrong (Longman) ; *Carbohydrates and Alcohol*, S. Rideal (Balliere, Tindall, and Cox) ; *Carbohydrates and Glucosides*, E. F. Armstrong (Longman) ; *Introduction to Chemistry of Cellulose*, March and Wood (Chapman and Hall).

Dyes and Dyeing. *Chemistry of Dyeing*, J. K. Wood (Gurney and Jackson) ; *Chemistry of Dye-stuffs*, Fort and Lloyd (Camb. Univ. Press) ; *Chemistry of Coal Tar Dyes*, I. W. Fay (Constable) ; *Analysis of Dyestuffs*, A. G. Green (Griffin) ; *Synthetic Dyestuffs and the Intermediate Products from which they are derived*, Thorpe and Linstead (Griffin).

Plastics. *Plastics*, V. E. Yarsley and E. G. Couzens (Pelican Series) ; *Plastics Applied*, Ed. V. E. Yarsley (National Trade Press) ; *Synthetic Resins and Allied Plastics*, R. S. Morrell (Oxford Univ. Press) ; *Handbook on Plastics*, H. R. Simonds and C. Ellis (Chapman and Hall) ; *Modern Plastics*, Barron (Chapman and Hall).

CLASSICAL LITERATURE

GREEK and Latin Literature from Homer down to the great Roman satirist Juvenal are covered in this Course. Although the languages in which these literatures were written are no longer spoken, the literatures themselves are amongst the most imperishable possessions of mankind, and a knowledge of them, if only in translations, which are good and abundant, is essential to the intelligent enjoyment of English literature and the other modern European literatures which, in both form and content, are so deeply indebted to the writings of the ancient Greeks and Romans.

For the languages of Classical Literature the student should refer to the Courses on GREEK (*Vol. 3*) *and* LATIN (*Vol. 2*), *and, for the influence of the Classics on other literatures, to the Courses on* ENGLISH LITERATURE (*Vol. 2*) *and* FOREIGN LITERATURE (*Vol. 4*). *The Course on* DRAMA (*Vol. 5*) *contains additional information on the ancient Greek and Roman drama and its influence on the European drama down to our own time. The Greek and Roman philosophers receive further consideration in the Course on* PHILOSOPHY (*Vol. 2*).

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LESSON 1

Dawn of Greek Literature

By Classical Literature—in the most exclusive sense—are meant the Greek and Latin literatures that have come down to us from the ancient European world, the world before the disruption of the Roman Empire in the 5th century A.D.—the only ancient literatures, except that of the Hebrews, which have exercised an appreciable influence on the thought or the art of the Western world. Greek literature appears as a creation of the Hellenes themselves, Latin as the offspring of the Greek and also as the main direct source of all modern European literatures.

We call Greek and Latin dead languages, but our own language contains a great many slightly modified Greek and Latin words, and when new inventions are made we commonly find ourselves driven to give them a Greek or Latin name, e.g. " telephone," " submarine," or fall back on a hybrid like " television." The words " politics " and " ethics " are from Greek ; " religion " and " morals " from Latin. Our scholars are styled philosophers, doctors, scientists, theologians, or jurists, and we educate our juvenile population. We admire, criticize, or condemn the music, the architecture, the poems, the pictures, the statues of our artists. Except the word " are," every verb and noun in the last two sentences is from either Greek or Latin. The form of words has altered, but the languages still live in more than half the languages of Europe.

For that reason alone they would be worth studying, even if they had not given us a priceless literature. Something at least of that literature one can assimilate, even if in its classical form it is out of one's reach, though no translations can fully take the place of the originals. Moreover, since all the modern literatures were moulded first on Latin or Greek models, and since all abound in Latin or Greek reminiscences or allusions, there is much in our English literature that cannot be fully appreciated by those to whom the classics are a sealed book. The primary purpose of this Course is to give such students a glimpse of its fascinating pages, in the hope that they will be encouraged to explore further.

Homer

Greek literature, as first encountered in the Homeric poems, has nothing embryonic about it—artistic expression has been already achieved, without a trace of external influences in the achievement. Homer's two great epics, the *Iliad* and the *Odyssey*, have never been surpassed in their kind. They are two long narrative poems which display in perfection every quality that a great narrative poem ought to possess : absorbing interest, continuity, dramatic action, convincing truth to life (which is not the less convincing for its inclusion of supernatural agencies and personages, in characters, actions, and surroundings) ; in a verse-form perfectly adapted to the dialect in which they were composed, never monotonous and always musical ; and having always that charm of spontaneity and inevitableness which belongs to the most consummate art. From the study of these two poems later critics formulated the rules which should govern the construction of a great narrative poem in the grand manner.

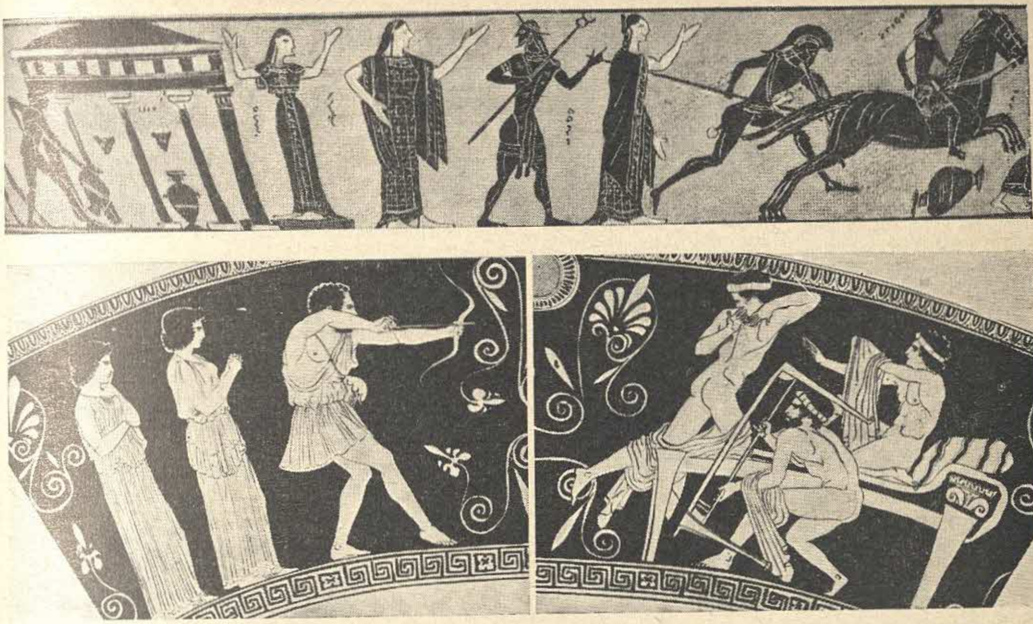
The Homeric Problem

We have spoken of Homer's two epics and of the Homeric poems to mark a distinction. The Greeks spoke and thought of the epics as the work of one poet. The other poems called Homeric they attributed, though not with the same confidence, either to Homer himself or to contemporary imitators. As to Homer's personality, no definitely ascertained facts survived. Tradition affirmed that he was blind and that he was born in one or another of seven or more cities, of which Chios and Smyrna were perhaps the most favoured claimants to the honour.

Critical examination of the epics, however, has led sundry scholars to challenge the whole tradition ; to declare that each epic was a collection of older ballads cleverly strung together, or an amalgam of two or more long poems, or at least that the authors of the *Iliad* and the *Odyssey* were two different persons. On the other hand, scholars no less eminent hold that while there are manifest unlikenesses between the two poems, these are sufficiently accounted for by the differences in subject and in the age of the author at the times when they were composed ; that they share in a very high degree characteristic qualities that could hardly have been combined in two different persons ; and that whatever accretions or interpolations may be suspected in the texts as we have them, or however diverse the sources drawn upon, each has a fundamental unity in conception, design, and treatment, impossible if they had not been the creations of one supreme genius.

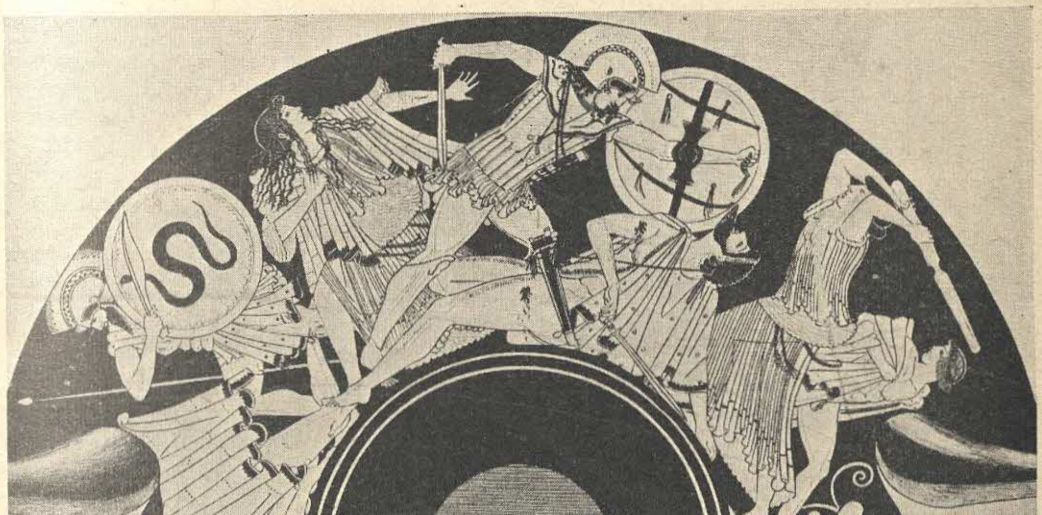
The Iliad

The *Iliad* is the tale of Troy (Ilion), or that part of it which centres on " the wrath of Achilles, terrible, bringer of woes unnumbered on the Achaeans," of the battles between the very human champions of either side, and the



HOMERIC STORIES. Top. Vividly depicted on a Grecian vase, Achilles pursues Troilus across the Trojan plain: an episode from the "Iliad." Lower. In this ancient vase-painting, the original of which is in the Berlin Museum, is seen Odysseus slaying one by one the all too persistent suitors of Penelope, his wife.

From Furtwängler-Reichhold, "Griechische Vasenmalerei," Bruckmann



WOE TO THE CONQUERED. Arctinus of Miletus, who flourished about 744 B.C., was one of the Cyclic poets whose appearance was the first proof of Homer's great influence on Greek literature. Arctinus wrote two epics: the "Aethiopis," taking up Homer's narrative from the close of the "Iliad," and the "Sack of Troy." Episodes from the latter work are illustrated in this Attic vase in the Louvre.

From Furtwängler-Reichhold, "Griechische Vasenmalerei," Bruckmann hardly less human Olympian gods intervening on behalf of their mortal favourites, each of whom is a clear-cut character, a living type to-day even as three thousand years ago, from Agamemnon, King of Men, down to Thersites, the type of vindictive scurrility.

The Odyssey

The *Odyssey* is the tale of the wanderings and the marvellous adventures of "the ever-resourceful Odysseus" after the fall of Troy, and of his homecoming. Full of vivid pictures of early Greek life in peace and war, it incidentally and charmingly portrays the delightful maiden Nausicaa, Penelope the indomitable, and the faithful henchman, the swineherd Eumaeus, not forgetting Odysseus' old dog.

In the hands of Homer and in the Greek tongue generally, the Homeric hexameter is a supreme instrument of music ; but in no other language except Latin has it proved adaptable to great poetry. "Silent he strode on the sand by the billows' boiling and hissing" is but a poor version of the line it seeks to translate. Longfellow used the hexameter for *Evangeline*, Kingsley for *Andromeda*, Clough for the *Bothie*, and sundry Elizabethans tried in vain to domicile it in England. But it remains inimitable and unapproachable.

The pleasure which can be drawn from reading Homer in the original Greek is incommunicable. Readers who have acquired sufficient Greek to do so only with difficulty may profitably accompany their study by using the prose translation of Andrew Lang (associated with S. H. Butcher in the *Odyssey*, and with W. Leaf and E. Myers in the *Iliad*), as in these a deliberately archaic style was adopted as best fitted for rendering an archaic dialect with the exactitude at which the translators aimed. Perhaps the most Homeric English translation, though certainly not the most literally accurate, is still that of the Elizabethan poet, Chapman, praised by Keats, Coleridge, and Lamb. The *Iliad* and *Odyssey*, however, were transmuted into English classics by Pope's very un-Homeric translation, which is nevertheless excellent reading, written in the heroic couplets of which Pope was a consummate master—an artificial form very inappropriate to the simplicity of the Homeric age. For though Homer himself lived long after the historic siege of Troy, he lived centuries before the full development of the Hellenic civilization.

Homer is a poet for all time; but he was primarily the poet of all the Hellenic peoples, because he sang of the legendary heroic age which was the common heritage of all Hellenes. He was their common possession, just as Shakespeare is the common possession of all English-sprung peoples. Yet those peoples were diverse and their literature was diverse after his day till, in the 5th century B.C., Athens became their centre, following the great wars against Persia which won freedom for Greece and ushered in her Golden Age.

LESSON 2

The Widening Range of Poetry

THERE were poets before Homer and ballads before the *Iliad*; but the ballads are lost, and for the names or works of the poets which have come down to us we have no authority but legends. What we can be sure of is that a period, in which the primitive ballad developed into the epic, culminated in Homer ; and that Homer was of the Ionian branch of the Hellenic race.

Hesiod

The next poet we encounter is Hesiod, and he belonged to a different branch, the Aeolian. He was born and bred in Boeotia, probably at least a century later than Homer. For his poems, known as the *Works and Days* and the *Theogony* (Birth of the Gods), he used the hexameter like Homer ; but in the *Works and Days* he is concerned not with heroic adventure but with the practical problems of the agriculturist. The Latin poet Virgil, when he wrote his great epic (the *Aeneid*), made Homer his model ; but for the poems which we call the *Georgics* or *Bucolics*, poems of country life and occupations, Hesiod was his forerunner. The lines of the following fragment of translation would be hexameters, but that a syllable is dropped at the end :

Pray to the earth-lord Zeus, and the great earth-mother entreat
So to make heavy her glory, the full-ripe ears of the wheat.
Pray at the first of the ploughing, with hand on the plough-tail's point,
Goading the backs of the kine, while the yoke thongs strain on the joint.

The *Theogony*, on the other hand, is a sort of summary of the current beliefs about the birth of the Olympian gods into a world which they controlled but did not create ; and it became, as it were, the standard text-book on the subject. Hesiod, in short, is much given to instruction and reflection, in which his greater predecessor very rarely indulges ; he is the first of the Greeks who is of set purpose "didactic." Homer's gods and goddesses are not, except on rare occasions, even edifying. They behave now as gods, more often as mischievous, more powerful men.

Greek was the common speech of all the Hellenic peoples, but of those peoples there were three main divisions, the Aeolian, Ionian, and Dorian, with corresponding dialects or variations in their ordinary forms of speech. But the influence of such pre-eminent and universally popular poems as those of Homer made his Ionic the model which was followed by other poets whenever they were dealing with themes similar to his, though it might be tinged with their native Aeolic or Doric ; while for other songs, more spontaneous and less imitative, they would use the forms which rose more naturally to their lips.

Thus the works of the Aeolian Hesiod are of set purpose more Ionic than Aeolic, and yet at the same time have a Doric tinge, because a part of the poet's life was passed among Doric-speaking folk. Homer's Ionic was the literary language of Hellas till new standards were set up by the modified Ionic of Athens, which for most purposes fitted itself more readily to other metres than the epic hexameter. All the literature which emanated from Athens was written in this Attic-Ionic, which is commonly known as classical Greek.

Birth of Lyric Poetry

After Homer and Hesiod nothing probably that has come down to us can be dated earlier than the 7th century B.C., when the historic city states of Greece had reached an advanced stage of political development, many of them having already a very marked individuality. The 7th and 6th centuries B.C. are the presumed period of the so-called " Homeric Hymns," or addresses to one god or another in the Homeric style. But in this period new verse-forms were also developing, the first being—as might be expected—a modification of the hexameter, which makes every alternate line a pentameter instead. Coleridge has supplied a typical couplet :

In the hexameter rises a fountain's silvery column,
In the pentameter aye falling in melody back.

This form is called the elegiac couplet. It was used comparatively little for narrative, but it was well suited for reflective poetry and the expression of the softer emotions rather than of passion. Tyrtaeus used it for some stirring battle songs at the beginning of the period, and Mimnermus and Simonides for noble memorial verses of the type to which we have appropriated the name elegy : and, being fitted at once for singing and for the expression of personal emotions, it opened the era of the poetry which is properly called lyrical at the time when verse and instrumental music were becoming very closely linked. So, also, at the close of the 7th century, new lyrical forms expressive of more fiery passions were being evolved, of which we have splendid examples in the surviving fragments by two (Aeolic) Lesbians, Alcaeus and the poetess Sappho. The Alcaic and Sapphic stanzas have never been naturalised in English ; but Tennyson's lines to Milton, " O mighty-mouthed inventor of harmonies," and Swinburne's " All the night sleep came not upon mine eyelids," are respectively outstanding examples.

Influence of Music

All this meant that the uses of verse were expanding and were therefore calling for new forms. The development of music gave an impulse to verse intended for choral singing in connexion with religious ceremonial, lyric in character, which was to be a most essential feature of the Attic drama. Of such choral hymns, to which the rather harsh Doric dialect was the best suited, we have only 6th century fragments by Arion, who, though a Lesbian, used the Doric for this purpose. By him and the Sicilian Stesichorus the special technique required by these chorus hymns or dithyrambs, which were composed for the worship of the wine-god Dionysus, is said to have been perfected.

Beside the lyrical advance of these two centuries there grew up another verse-form, the iambic metre, based, like English blank verse and the heroic couplet, not on the combination of the dactyl—a long or stressed syllable followed by two shorts, e.g. cheerily—and the spondee—two longs, as war-lord—but on the iambus, a short followed by a long, e.g. alone. The English metres have five such " feet " to the line ; the standard Greek iambic line has six. This seems to have been used first as a medium for a new type of poetry, the satire. Of this there remain only fragments ; but the iambic was destined to become essentially the metre of dramatic dialogue. We may note in passing that rhyme never enters into the scheme of Greek poetry.

Pindar

We close this study of early poetry with the poet whom Hellas most delighted to honour as her national lyrist, Pindar (*c.* 522–443 B.C.). Throughout the first half of the 5th century Pindar was writing the choral odes—in celebration, nominally at least, of victors in the Olympic or other public games—so curiously bound up with Hellenic ideas of nationality and religion, on which his fame chiefly rests. (There is a fine prose translation of the Odes by E. Myers.) In fact, they celebrate the legendary, but to the Greeks very real, heroes of tradition. One must be steeped in the Hellenic atmosphere before one can fully appreciate them or understand their imaginative fascination, but the Pindaric Odes remain above challenge as supreme achievements of the singer's art.

LESSON 3

Greek Tragedy and Comedy

No modern dramatist, writing for the stage, would dream of taking a Greek tragedy or comedy as his model, for the Greek drama came into being under conditions totally different from those which control the writing of a modern play. It originated in a form of religious service in honour of the wine-god Dionysus, or Bacchus, about whose altar, on the festival day, a trained chorus chanted choral hymns or odes of a lofty character, but closing with one on a lower plane in which the singers were clad as satyrs, the wild woodland companions of the god.

TRAGIC ACTOR. Ivory statuette with piled-up hair and high-soled buskins, which give added height.
Furtwängler-Reichhold

These dithyrambs were the precursors of the drama. Thespis was the name of the traditional author of the innovation by which the intervals between hymns were filled in by the recitation of some heroic legend. Tradition again said that a second reciter was introduced by Aeschylus himself, the first and from one point of view the greatest of all tragedians. The recitation, in the iambic metre, became a dialogue in which the reciters, soon increased in number to three but no more, impersonated the principal persons in the story, which itself became a story in three divisions, a trilogy, each division being what we now reckon a separate play, a distinct phase of the single heroic theme; the whole being still followed by the satyric piece.

The effect was that the relation between song and narrative became reversed; the song became the supplement of the drama, the acted narrative. The only complete trilogy which has come down to us is the *Oresteia* of Aeschylus, the tragedy of the house of Atreus; the separate plays being the *Agamemnon*, *The Libation Bearers*, and *The Eumenides*. Our one satyric piece is the *Cyclops* of Euripides, unless his *Alcestis* should be reckoned as a second.

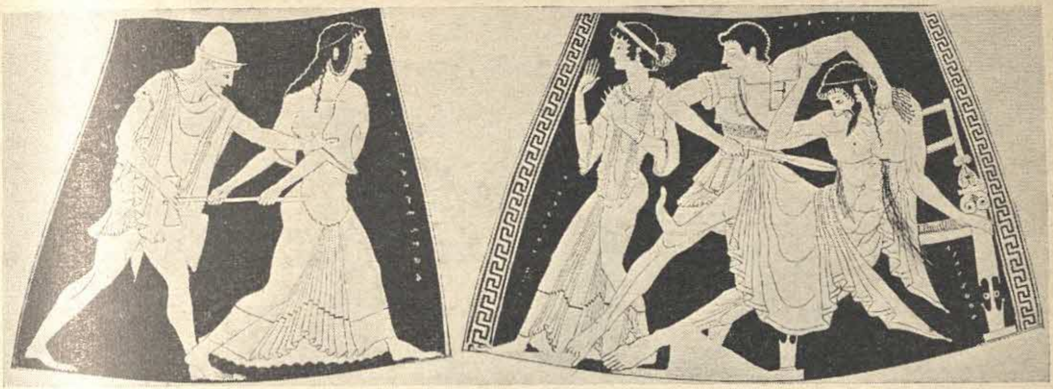
This drama was to be presented in the open air, usually before an audience numbering not hundreds but thousands, in a moral atmosphere something like that which would accompany a play dealing with the story of Samson or King David or the house of Omri—charged with the idea of obedience to the divine law. The presence of the chorus is an essential part of it. The business of the actor is restricted, as in an opera, by the musical conditions, but also because his impersonation must be statuesque rather than active and his speech declamatory or, in dialogue, very clear-cut.

The chorus also has its own part to play. Its members are not actors. Practically their songs are a poetic commentary on the action of the drama, explanatory and allusive, interposed between the acts, sometimes with the simple purpose of relieving a tension which might otherwise become unbearable, since such "comic relief" as Shakespeare employs would be out of place. But the leader of the chorus occasionally intervenes in the dialogue to ask or give information, the story enacted being in its main features already familiar to the spectators, while the interpretation of it is the author's own. To the Athenian audience the choral poetry was as essential as the action, much of which is reported instead of taking place on the stage; but on a modern stage it is hardly imaginable. Where moderns have directly sought to follow the Attic model, they have produced great poetry but not great drama. Milton's *Samson Agonistes* is perhaps the supreme example.

The Thirty-Three Tragedies

The surviving Greek tragedies number thirty-three, all of them by one or other of the great trio, Aeschylus, Sophocles, Euripides, and all produced between 500 and 400 B.C. At each

TRAGEDY ON A VASE. Fifth-century vase-painting shows one legend on which dramatists based their plots.



LEGEND OF ORESTES. Both Aeschylus and Euripides based trilogies on the legend surrounding Orestes, and Sophocles dealt with it in his "Electra." This vase-painting depicts Orestes pausing in the act of stabbing Aegisthus to watch his mother, Clytaemnestra, who threatens him with an axe.

From Pfuhl, "Masterpieces of Greek Drawing and Painting," Chatto & Windus

annual festival of the Dionysia three trilogies were presented, selected from many more competing for a prize by judges who were not infallible. Among the vast number of plays produced during that period by the same or other authors, there must have been some worthy to rank with these, though none survives.

In the hands of Euripides, in the second half of the century, the drama was taking a new character much more akin to modern ideas than was the case with his predecessors. The old vein was becoming exhausted, tragedy was tending to romance, and romance never achieved the same triumphs. It was the decadent tragedy that the Romans imitated, and it was from the Roman tragedy that modern tragedy took its rise, to develop on lines of its own.

AESCHYLUS (525–456 B.C.), first great Greek playwright.

Aeschylus

Turning now to the poets themselves, we come first to Aeschylus (525–456 B.C.), the earliest, simplest, and grandest of the three; simplest, however, only in the sense that he is the least complex, both in method and in motive, since his work abounds in passages of extreme difficulty, while the splendour of his language is as impossible of reproduction in another tongue as Shakespeare's, though it would be hard to excel the quality of Morshead's translation (Golden Treasury edition).

Aeschylus competed for the first time—unsuccessfully—for the tragedy prize when he was twenty-five, in the year of the Ionic revolt against Persia in which Athenian troops took part. The earliest play surviving, *The Suppliant Women* (the daughters of Danaus), is dated in the year after the great Athenian victory over the Persians at Marathon, in which the poet himself was fighting. Some ten years later he fought in the victorious battles of Salamis and Plataea, whereby he was inspired to write a trilogy on the Persian war itself, of which one play, *The Persians*, survives. The *Oresteia*, probably his last work, was produced about twenty years after Plataea. The connexion between the Persian war and the efflorescence of the Athenian drama bears a marked resemblance to the corresponding efflorescence of the Elizabethan drama in England. From *The Suppliant Women* to the *Oresteia* one can trace the development of the drama from almost the first introduction of two actors to the magnificent climax it attained while Aeschylus was still living.

Of his first play, *The Suppliant Women*, it is enough to say that the chorus itself represents the fifty Danaides, while the characters represented by the actors have comparatively little to say or do; drama as the poet's instrument is still in the making, whereas in the *Oresteia* and especially in the *Agamemnon* it has been perfected. There the figures are consistent, definitely marked human characters, tremendously conceived; and it is on their action, whether on the stage or as descriptively reported, that the interest concentrates, though the choral accompaniment is almost unapproachable in its magnificence and impressiveness, even in translation.

But to Aeschylus the story, which probably every tragedian, certainly Sophocles and Euripides, attempted to treat in his own way, is primarily a supreme illustration of the universal law that he who sets at naught the fundamental decrees of the eternal Righteousness which reigns over both gods and men is working woe as certainly for himself as for others—not because the gods intervene to inflict punishment, but because the suffering is the inevitable fruit of the sin, until the sin has been expiated. It is a law implicit in tragedy, in Shakespeare's historical plays as well as in the tragedies proper ; but Shakespeare leaves us to discern it, whereas Aeschylus makes it emphatically explicit through the poetry of the chorus.

SOPHOCLES (495–406 B.C.), great tragic poet.

Before turning to the successors of Aeschylus a word must be said of another of his plays, the *Prometheus Bound*, which is the story of the doom brought upon himself by the Titan Prometheus who did the right in defiance of the supreme Olympian god. It is not sin only that brings woe; that is the eternal mystery for which the facts of life offer no solution, nor does Aeschylus solve it. It was, however, his presentation of the problem that inspired Shelley to write *Prometheus Unbound*.

Sophocles

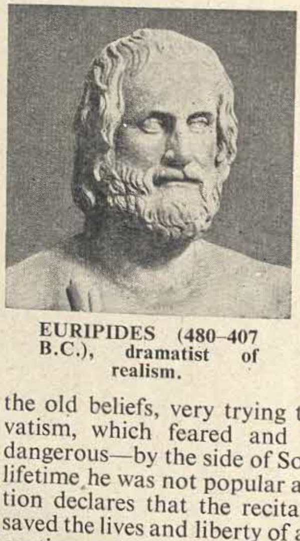
Sophocles (495–406 B.C.) was younger than Aeschylus by thirty years ; it is therefore not surprising that if Aeschylus was the greater creative genius, the more sublime poet, and the more profound thinker, Sophocles was the more consummate artist. Of his tragedies only seven survive. His stagecraft was unrivalled, and if he did not move in the same heights and with the same mastery as Aeschylus, he was the perfect embodiment of that essential virtue of Hellenism and indeed of all artistry which the Greeks called *sophrosyne*. For this there is no equivalent English word. It is perhaps best explained as the sense of proportion, harmony, balance, fittingness, which, without loss of power, instinctively rejects all that is turgid or exaggerated. It is this that gives to his tragedy a certain serenity which the tempestuous soul of Aeschylus could never have achieved, though we can never quite feel him to be tremendous as Aeschylus habitually is. When Shakespeare attained his final serenity, he ceased to write tragedies.

The three plays on the tragedy of the house of Oedipus—*Oedipus the King*, *Oedipus at Colonus*, and *Antigone*—did not form a trilogy in the strict sense ; they were written at different periods. But as a group they are the masterpieces of Sophocles, and the first was obviously in the mind of Aristotle when he laid down the ruling principles in the construction of tragedy. The doom which falls upon Oedipus is the penalty for a " deed without a name," done in innocence but none the less unpardonable. This is in perfect accord with the orthodox Greek idea of divine justice, though to the modern reader it may militate against full acceptance of the tragic theme. The guilt, however innocently incurred, demands the same fullness of expiation. But if that difficulty is conquered, the reader will probably endorse the verdict which accounts *Oedipus the King* the most perfectly constructed of all tragedies.

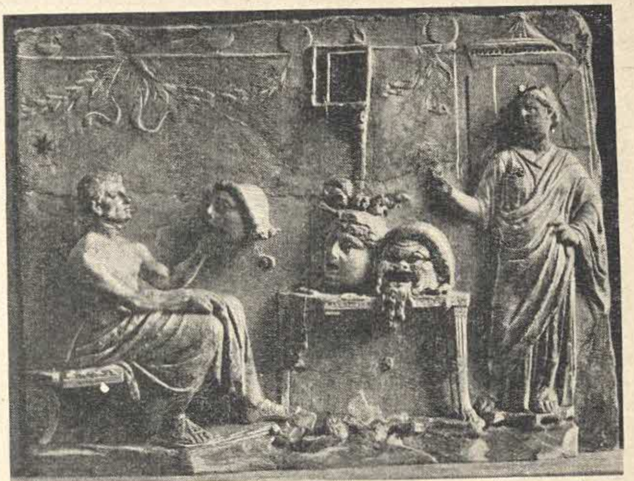
Otherwise he may be more profoundly moved by the *Antigone*—the story of the sister who gives her own life in fulfilling the duty of giving the God-ordained burial rites to the brother to whom those rites are forbidden by the law of the country, though neither man nor woman will dare to take her part. There is an excellent translation of Sophocles' plays by Whitelaw.

Euripides

From the sublimity of Aeschylus and the perfection of Sophocles, turn now to Euripides (480–407 B.C.), " the human, with his droppings of warm tears," of whose plays many more survive than of his mighty predecessors. His idea of the functions of tragedy is much more modern than theirs ; the overruling sense of the divinity that shapes our ends gives place to the consciousness of moral problems as perplexing rather than terrifying. He is moving at least in the direction of romance. The atmosphere is no longer exclusively heroic, since to him the heroes of legend have ceased to be heroic.


EURIPIDES (480–407 B.C.), dramatist of realism.

Aeschylus and Sophocles accepted without question the beliefs of their fathers, while reading into them a profounder meaning ; but the plays of Euripides are a criticism of the old beliefs, very trying to Athenian conservatism, which feared and denounced him as dangerous—by the side of Socrates. During his lifetime he was not popular at Athens, but tradition declares that the recitation of his *Alcestis* saved the lives and liberty of a crowd of Athenian captives at Syracuse. If Aeschylus is tremendous by reason of his faith, Euripides is great by reason of the intensity of his human sympathy. He anticipated Shakespeare in the mingling of the



DRAMATIST STUDYING MASKS. This relief represents a comic poet, possibly Menander, studying masks for one of his plays. In Athenian comedy certain stock characters were recognizable from the features of their masks.
Lateran Museum, Rome

pathos of common persons and common things with the awe of the heroic.

Several of his eighteen (or nineteen) surviving plays have been admirably rendered into English by Professor Gilbert Murray. The best introduction to him will probably be found either in the *Medea* or the *Alcestis*, the latter of which Browning translated after his own fashion in *Balaustion's Adventure*, a happier effort than his *Agamemnon*. In both plays the central figure is a woman : Medea, a wife cruelly wronged, who takes a terrible revenge ; Alcestis, a wife who deliberately chooses to die that her husband may live. Medea's hesitation before she commits her awful crime suggests in some sort Lady Macbeth's remorse which is not repentance. The nobility of Alcestis is brought into higher relief by the picture of the husband who persuades himself that it is he who is making the greater sacrifice in accepting hers. But the *Alcestis* is ultimately not a tragedy but a romance, since she is restored to the living world by the intervention of Heracles ; and here we have a play in which the comic element is so prominent that the play may be an example of the satyric, as the *Cyclops* certainly is. The *Bacchae* and the *Trojan Women* (both translated by Murray) are perhaps greater plays.

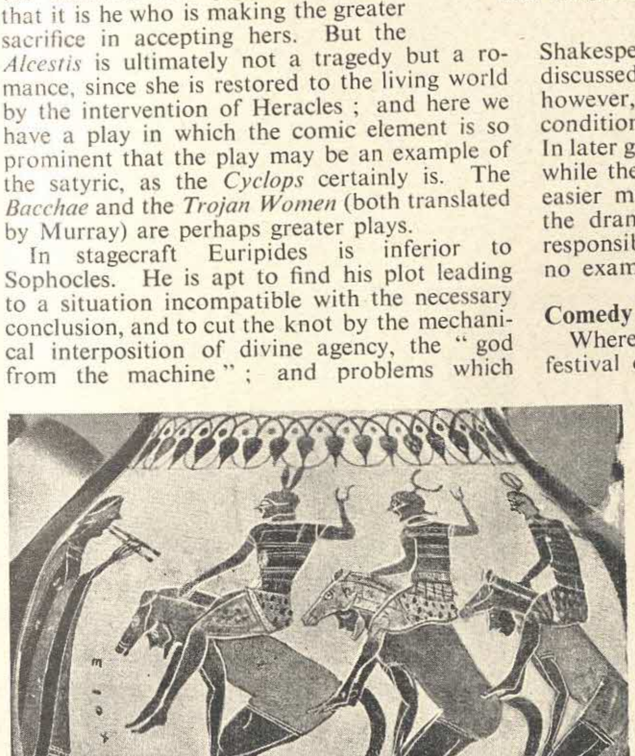
In stagecraft Euripides is inferior to Sophocles. He is apt to find his plot leading to a situation incompatible with the necessary conclusion, and to cut the knot by the mechanical interposition of divine agency, the " god from the machine " ; and problems which Shakespeare would deal with in soliloquies are discussed in debating speeches—which may, however, have been better suited to his stage conditions, though they interfere with the action. In later generations Euripides was more popular, while the latitude of his methods made him an easier model to follow ; but the decadence of the drama after his day, though he was not responsible for it, is indicated by the fact that no examples of it survive.

Comedy

Whereas tragedy originated in the spring festival of Dionysus, comedy had its origin in the harvest festival of the same god when revelry was to the fore—not in the satyr plays which accompanied the spring tragedies. Almost all that has survived of the Old Greek comedy would seem to have begun (though, of course, he had predecessors) and ended with one man, Aristophanes (*c.* 445–*c.* 388 B.C.) ; though of it was begotten the New comedy of manners—of which there are scant remains—whose chief exponent was Menander (342–291 B.C.), the model of the later Latin comedians from whom modern comedy derives (*see* Lesson 7).

Aristophanes

In the hands of Aristophanes comedy was a social or political satire set forth by the method which the tragic drama had made familiar, of combined dialogue and choral song, to which the nearest approach is to be



GREEK COMEDY ON A VASE. Vase-painting showing the exuberant buffoonery of the Old Comedy.

ARISTOPHANES (c. 445–388 B.C.), chief representative of the Old Comedy.
Capitoline Museum, Rome

found in modern musical comedy. The genius of Aristophanes allowed his imagination to run riot; his choruses are storks, wasps, frogs, clouds; his characters include prominent persons, dead or living, especially such as he chooses to pillory—Cleon the demagogue, Socrates, Euripides — mingled with ordinary Athenian citizens, slaves, etc.; while his choruses are interspersed with lyrics that are sometimes exquisite.

There is an entire absence of reticence or reverence, except for the good old days when gentlemen were gentlemen, not snobs or profiteers. Flagrant buffoonery is mingled with wit and humour, die-hard conservatism with acute political comment; though Socrates is a charlatan, Aeschylus is acclaimed, not without some penetrating criticism. Side by side with a coarse passage comes the chorus of clouds:

> Clouds ever fleeting are we,
> And we rise into light
> In our dewy forms bright
> From the arms of our father the thunderous sea.

The plots are merely fantastic. In the *Frogs* the god Dionysus pays a visit to the underworld, Hades, and is arrested by the local police on suspicion of being Heracles the dog-stealer; in the *Birds* two Athenian citizens, bored with Athens, seek new quarters in Cloud-cuckooland. These two, with the *Clouds*, probably give the liveliest and most attractive introduction to Aristophanes. (Murray, whenever available, is always the best of translators.) The Athens depicted is always the Athens of the last quarter of the 5th century B.C. But Aristophanes was unique in his individuality.

LESSON 4

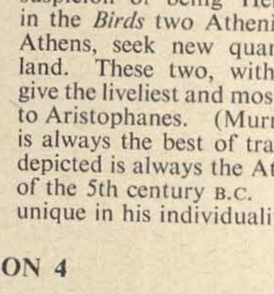
Early Greek Historians

IN the 5th century B.C., after the tragic drama had attained fulfilment, the Greeks created literary history—history, that is, which is not a bare chronicle of events, but gives their presentation a literary form with the intention of making the record not only truthful but interesting and instructive, so that it may be, as Thucydides said of his own work, a possession for ever. Of such history there are primarily two kinds: the picturesque, which aims at vivid narrative and lively portraiture, concentrating on what may be called the human interest; and the scientific, which is more concerned with principles and causes, with political rather than personal aspects. In each kind Greece produced the first and perhaps still unsurpassed master.

Herodotus

Herodotus (*c.* 484–424 B.C.) was born in the Doric city of Halicarnassus, but his life was spent elsewhere. He travelled over all the Hellenic world, from Italy to Asia Minor, into Persia proper and Egypt, and into barbarian Scythia beyond the Danube, and possessed an insatiable appetite for seeing and hearing everything that was to be seen or heard. He had an enthusiastic admiration for Athens, though he wrote not Attic but Ionic Greek, occasionally using Homeric forms.

He set out to write an account of the struggle between Greece and Persia, which had come to its triumphant climax when he was five years old; but he is half-way through his nine books before he reaches the Ionic revolt, which was the direct Greek challenge to the Persian. Meanwhile he has recounted the story of Cyrus the Great and the rise of the Persian empire, with digressions on the history or legends of Babylon, Media, and Phrygia; its expansion to Egypt, with an account of Egyptian history derived from what he had seen and heard in Egypt itself; the attempt at a European expansion by Darius, leading to a discourse on the manners and customs of the Scythian barbarians; and anecdotes about various Greek celebrities of the past.



HERODOTUS (c. 484–424 B.C.), known as "the Father of History."
Metropolitan Museum, New York

Herodotus reports what he saw with picturesque fidelity; what he was told, with polite but humorous hints of scepticism—recording the trivial and the marvellous with perfect gravity and naïveté and with obvious enjoyment, indulging in no romance on his own account, but accepting it joyously when he lights upon it. And when he does come to the story of the great war, he tells it in the same spirit, but with an added enthusiasm, especially where Athens is concerned, because in his eyes that city bore the brunt of the battle for the liberation of Hellas from the yoke or the threatened yoke of Persia. But there is no depreciation of the enemy and his good qualities, and in the earlier portion he is as enthusiastic about Cyrus as if that king had been an Athenian. The story told in the last four books is one of the most thrilling and dramatic in all history. A good translation of the *History of Herodotus*, by A. D. Godley, is in the Loeb Library.

Thucydides

From the far-travelled Herodotus—whose work is almost as much the first book of travels as the first history, though not the less Hellene for his cosmopolitanism—turn now to the Athenian, Thucydides (*c.* 460–*c.* 400 B.C.), who in the judgement of Macaulay was the greatest historian of all time; though he was certainly wrong in regarding the subject he treats, the struggle for supremacy among the Hellenes between Athens and Sparta, as of more importance than the Persian war.

Nevertheless, his study of the Peloponnesian war is not only of great historical value in itself. In it he adopted a method of treating history which is more valuable than the subject he treated; while his handling of the subject makes the work a literary masterpiece, in spite of an occasional crabbedness of style in the interests of compression, which conveys in a phrase or a sentence what an ordinary writer would have required a paragraph to express, and at times breaks grammatical rules for the sake of brevity.

THUCYDIDES (c. 460–400 B.C.), historian of the Peloponnesian war, who prefaced his record with a survey of Greece before his time.

Capitoline Museum, Rome

Thucydides has, in the first place, a story to tell that abounds in dramatic episodes, which he depicts with dramatic vividness; the sixth book taken by itself satisfies the highest requirements of Aeschylean tragedy. It tells how the Athenians, deserting the idealist imperialism of their dead leader Pericles, embarked in overweening confidence on a career of unwarranted aggression; how they staked everything on a wanton attempt to subject Sicilian Hellas to their own sway; how in spite of reckless blundering they came near to attaining their purpose; how Syracuse was saved by the skill and daring of a great Spartan soldier; how the Athenian host became demoralised; how the moral rectitude of their unwilling commander Nicias failed to avert the disaster for which his own inefficiency was chiefly responsible; and how overwhelming that disaster was when the hour struck.

The tenseness of tragedy runs through it from start to finish with the perfection of the story-teller's art and without rhetorical embellishment, gripping the reader all the time. The Sicilian expedition which shattered imperial Athens is, however, only one episode, if the most tremendous, in the Peloponnesian war and in the narrative of its historian.

Secondly, he writes always with a completeness of detachment which is well illustrated by his brief account of the episode in which he was himself outwitted by the great Spartan general Brasidas. Here every one of his readers would know, though no one would guess from the telling, that he was the Athenian commander concerned. His description of Athens under the plague (Bk. 2) is as convincing as Defoe's account of the Great Plague of London.

Then Thucydides was a master of description. Nothing could be more vivid, for instance, than his story of the escape from Plataea (Bk. 2). His presentment of the Corcyrean revolution with his reflections thereon (Bk. 3), and of the discussions at Athens on the policy to be pursued in relation to Mitylene and Melos, are profound expositions of political psychology; the funeral oration which he puts into the mouth of Pericles (Bk. 2) as a eulogy of the Athens he led and loved is an idealist's picture in noble contrast to the Melian dialogue.

He was not a mere chronicler, a teller of interesting stories, but one who had a high conception of the historian's function. "I have described nothing," he said, "but what I either saw myself or learned from others as the result of the most careful and particular inquiry." With good reason has he been described as the first of critical historians.

The ancient historians, it must be noted, are not to be charged with inaccuracy in putting into the mouths of statesmen and generals speeches which were certainly never delivered in that precise form; there were no shorthand or authentic reports to consult. These speeches are simply the writer's expression of the views he attributes to the supposed speaker; and this holds good as a matter of course with all historians before modern conditions made it possible to reproduce the spoken words.

Xenophon

A third author, Xenophon (*c.* 430–*c.* 345 B.C.), was not a creator, but for us he is the first example of the man of letters whose range of interests is wide, who does many things well but none supremely well. His most notable work, commonly known as the epic *Anabasis*,

ISOCRATES (436–338 B.C.), who wrote pamphlets in speech form which profoundly influenced Cicero.
Villa Albani, Rome

i.e. the march up country, is the story of the March of the Ten Thousand which he joined as a volunteer, and of which he later became the commander. He wrote a continuation of Thucydides called *Hellenica*; he studied philosophy, not very deeply, and produced *Recollections of Socrates*; and he wrote the *Cyropaedia* (the Education of Cyrus), which might be called the first historical novel, to set forth his ideal of training for kingship.

All these works deservedly survive; all are good reading; all are written in a style which is simple, lucid, and sometimes, especially in the *Anabasis*, vivid and picturesque. The excellence of his Greek makes his books perhaps the best introduction to the study of the language; but they are not great literature in the same sense as are the works of Herodotus and Thucydides, Plato, or Demosthenes.

Isocrates

The Athenian citizen was expected to take an active part in public life; speech treated as an art was part of the higher education; and it was to this art and the teaching of it that another Athenian, Isocrates (436–338 B.C.), devoted himself, unsuccessfully as a practitioner, successfully as a teacher. His works are written speeches, most of which, including the most notable, the *Panegyricus*, in which he extols Athens as the natural leader of Greece, were never delivered. For him a speech was a literary production and perfection of style the master aim; so that the greatest of Roman orators, Cicero, made him his own model. The political speeches were, in fact, intended to be pamphlets, though cast in orthodox speech-form; and their merit is the merit of all elaborated prose style and rhythm. With Xenophon and Isocrates we have passed from the 5th into the 4th century.

LESSON 5

Philosophers and Orators of Ancient Greece

The names of Socrates (*c.* 470–399 B.C.) and his pupil Plato (*c.* 427–347 B.C.) are inseparable. Socrates talked; Plato not only talked but wrote; and what he wrote he would have us believe he learnt from his master. How much of it is Socrates and how much Plato, no man will ever know; but what there is of Socrates Plato made his own. The reader who has fallen under Plato's spell will never escape from the enchantment, finding in him the master thinker endowed with " the vision and the faculty divine," ever in pursuit of spiritual truth, which is eternal and unchanging, while the material is changeful and fleeting. Reality is in the idea; the things we see or touch are only its distorted reflections, by aid of which, rightly interpreted, we gradually recover the vision we lost when we were born.

Socrates and Plato

In the pursuit of truth one must begin by dissipating the errors which one is in the habit of mistaking for truths. Plato had learned his method from Socrates, whose habit of pulling popular errors to pieces had appeared to the authorities so subversive of all proper behaviour that he was condemned to death for impiety, in 399 B.C., when his greatest pupil was eight and twenty. Plato, no doubt, went much farther than his master in developing the constructive counterpart of this destructive criticism, but he makes Socrates himself the teacher. His many works take the form of dialogues or conversations in which Socrates is the principal speaker, along with the distinguished or popular teachers whose doctrines are to be demolished, or private friends and pupils of Socrates. The notable exception is the *Apology of Socrates*, the defence, or rather the justification, of his own career offered by him to the court which condemned him to death, when Plato was present. In some ways, therefore, this is the best introduction to the study of the Socratic or Platonic teaching. In it Socrates reveals his own character as Plato saw it; his philosophy was the product of his character; and the better one understands it the better one can appreciate his method, and the better chance one has of following up his philosophy.

Teachers before and after Plato have used the dialogue form; Plato achieved with it a unique success, because not only Socrates but everyone who takes a part is a living human character, while Socrates himself is that very rare being, a philosopher with an unfailing sense of humour, of a very high order, which lightens the strain of studying an abstruse subject. Apart from the subject, which loses nothing, the dialogue becomes a source of purely literary enjoyment, which is increased again by a finished style equally free from crabbedness and affectation ; while relief of another kind is supplied by occasional bursts of sublime poetry, though in prose form. The dialogues, written at different times over a period of some fifty years, themselves cover all sorts of ground—the theory of religion, sex, politics, ethics, of life and death, time and eternity, of knowledge itself.

Symposium, Republic, Phaedo

The most advanced Platonists might name the *Timaeus* as the crowning work ; but, apart from the *Apology*, the way to Plato is most readily to be found through the *Symposium* (Banquet), by reason quite as much of the characters who take part in it as of the actual discussion ; the *Republic*, in which he evolves the conception of a perfectly ordered state in order to discover the essential meaning of the four supreme virtues of man —a dialogue in which all Plato's own most characteristic qualities are consummately displayed ; and the *Phaedo*, which depicts Socrates in his last hours, surrounded by his sorrowing friends, expounding to them his doctrine of the immortality of the soul while the fatal draught of hemlock is doing its work. Although no translation can give the beauty of Plato's style in the Greek, the *Republic* may be read in Jowett's translation, in that of Davies and Vaughan in the Golden Treasury series, and of A. D. Lindsay in the Everyman's series. The philosophic content of Plato's work is discussed in the Course on PHILOSOPHY, Vol. 2, its political aspect in the Course on POLITICS, Vol. 5.

Aristotle

As Thucydides and Herodotus mark the two types of historical writing, so Plato and Aristotle stand for the two types of seeker after wisdom, those who start from the spiritual and the material respectively, who in their extreme forms might be called mystics and materialists. Aristotle (384–322 B.C.), who had the most encyclopedic mind on record, was the father of scientific method. No man has ever accumulated so vast an amount of the available information on so wide a variety of subjects as he, always collecting, comparing, classifying, reducing to order, distinguishing, co-ordinating, systematising. This collected information provides the data for science, of which there are four branches : the science of reasoning, to which the name logic was later given ; practical science, or the science of living, which includes ethics and politics, the life in and of communities ; constructive science, or the laws that govern art ; and theoretic science, embracing physics, mathematics, and metaphysics. Thus he maps out the whole field. Logic, which may be called the guiding science, he deals with in the treatises collectively known as the *Organon* (instrument), which by a curious fate came in the later Middle Ages to be regarded almost as divinely inspired and of incontrovertible authority. His notes on natural science and natural history were regarded as almost equally authoritative, till displaced by the advance of knowledge from Copernicus to Newton.

There remain his four treatises, the *Ethics*, *Politics*, *Poetics*, and *Rhetoric*. The translations of the first three, by Peters, Welldon, and S. H. Butcher respectively, can be recommended. In the *Ethics* he accepts and analyses the conventionally recognized virtues, and finds them to lie in a mean between two opposed vices. The Good for man is not pleasure or happiness, but the full development and exercise of his powers. The *Politics* are the conclusions drawn from an examination and comparison of the constitutions of more than 150 Greek states, no others being, in his view, worthy of consideration. In the *Poetics* he lays down the canons of composition exhibited by the examination of the practice of great poets, many of which hold good at the present day. The work is mainly a literary criticism of tragedy. Aristotle's *Rhetoric* is concerned with the arts of argument and persuasion. While it deals with literature, it is also a treatise on logical reasoning, and is thus of great value in oratory, an art which is not primarily literary.

DEMOSTHENES (c. 383–322 B.C.), greatest of all orators.
Vatican Museum

Demosthenes

Isocrates, as already said, survives not because he was a great orator but because he created a prose style which became the model of Cicero, whose own style eventually served as a general model for posterity. The speeches of Demosthenes (*c.* 383–322 B.C.), on the other hand, live because he was a very great orator, a speaker who combined clear, hard reasoning with an intense emotional appeal. He combined them so effectively, moreover, that although one is reading instead of hearing him, one is irresistibly carried away, and scarcely anyone can be found who has a good word for his political opponents, the objects of his fervent denunciations, concerning whom one might form rather different judgements, could one judge them on their actual merits.

Demosthenes was an Athenian patriot and, at all costs, the champion of a lost cause. In Philip of Macedon he could see only the ambitious tyrant whose aim was the enslavement of Hellas, and of Athens as the traditional champion of Hellenic liberties, the enemy whom it was the sacred duty of Athens to resist, whatever the consequences to herself. That is his attitude in the series of speeches against Philip, whose name Cicero adapted for his *Philippics*, which were, however, diatribes against Antony ; in common use the term " philippic " has come to be applied to rhetorical invective generally. This attitude finds its final expression in the speech " On the Crown," which is the orator's masterpiece, being his defence of the policy which he had persuaded Athens to follow, after it had issued in decisive failure. " The test of a policy," he asserts, " is not its success or failure ; win or lose, it is better to die for what we know to be the right than to triumph with the wrong ; we honour the Athenian heroes of Marathon and Salamis, not because they won, but because they staked their lives for liberty."

LESSON 6

Greek Literature in the Hellenistic Age

DEATH put a close to Alexander's conquest of the East in 323 B.C. Next year both Aristotle and Demosthenes died, and with them the giants of Greek literature came to an end. Greek literature, however, continued to be the dominating intellectual influence throughout the civilized East, and it also presided over the birth of literature in Rome and the West. But this new age, sometimes called Alexandrian, sometimes Hellenistic, was not, in fact, a creative age, though the name of the Sicilian Theocritus (*see* below), the originator of the idyll or pastoral, stands out as that of a great creative master.

Apart from Theocritus, literature was rather a pursuit than an inspiration. Research was publicly endowed, criticism flourished ; the new tendency was for creation to be overridden by learning. There was an abundance of professional men of letters and cultured amateurs ; the technique of verse-making (as opposed to inspired poetry) was carried to a high perfection, these later ages of Greek literature being chiefly concerned with tradition—the study and interpretation of the past.

Christianity and Platonism

The influence of Greek philosophies which obtained after Aristotle, however, mainly dominated serious thought till they were deposed by Christianity. Neither the mysticism of Plato nor the logic of Aristotle was adapted to be the base of a popular philosophy, though each had powerful attractions for great intellects. The Platonists always remained a select circle ; it is a notable fact that when Christianity became a missionary religion St. John's philosophical terminology was mainly drawn from Platonic sources, and much of the teaching of the early Fathers and early heretics was deeply influenced by the study of Hellenistic Platonism. On the other hand, for the educated pagan world philosophies had to provide the moral framework which had once been derived from religious conceptions already discredited.

Epicureanism and Stoicism

Thus for five hundred years the great influences were those not of Plato and Aristotle but of the " schools " founded by their successors—Epicurus, whose doctrines were called by his name, and Zeno, whose followers were the Stoics, named from the stoa (porch) where Zeno lectured. Epicureanism, which was far removed from the " let us eat and drink for to-morrow we die " view of life with which it is so commonly identified, gave birth to a great Latin poem, *De Rerum Natura*, by Lucretius, which is dealt with in Lesson 9. Stoicism, the puritanism of the ancient world, produced in the 2nd century A.D. the lectures of Epictetus which Arrian, the historian, shaped into the volume called *Encheiridion* (Hand-book), and the *Meditations* of the emperor Marcus Aurelius Antoninus.

The distinction between the two schools is clearly recognizable in modern thought. The Epicurean did not deny the gods, but he regarded them as aloof from human affairs, rejected the life after physical death, held pleasure to be the highest good, though he ranked the pleasures of the mind above those of the appetites, and had utilitarian views of morals and moral sanctions. The Stoic allegorised the old fables ; the gods stood for the Eternal Righteousness ; the highest good for man lay in the practice of virtue, the self-mastery which defies the distractions of pains and pleasures alike.

Theocritus

Turn now to the major achievements of the Greek authors of the Alexandrian period. Of these, as already stated, the work of Theocritus is the most notable. His creative artistry is consummate ; his metre is sheer music, and his word is not the correct but the perfect word. His idylls are vignettes of country scenes. The First Idyll, which contains the exquisite Lament for Daphnis the Shepherd, has provided a model for many elegies, Milton's *Lycidas* and Shelley's *Adonais* among them. For English readers he has been singularly happy in his translator, C. S. Calverley.

Callimachus

Among the many writers who enjoyed a very high reputation for a time was Callimachus (d. 240 B.C.), for years controller of the great library of Alexandria. Callimachus would seem to have been an acknowledged literary dictator and in his own writing a master of highly finished literary form. His hymns, brilliantly clever and erudite, but mannered, survive in their entirety. In one field, that of the epigram, which always flourishes when polish is the primary requirement, he attained an unsurpassed excellence. An example from an admirable English translation (by W. Cory) may be quoted :

> They told me, Heraclitus, they told me you were dead ;
> They brought me bitter news to hear and bitter tears to shed.
> I wept as I remembered how often you and I
> Had tired the sun with talking and sent him down the sky.
> And now that thou art lying, my dear old Carian guest,
> A handful of grey ashes, long, long ago at rest,
> Still are thy pleasant voices, thy nightingales awake,
> For Death, he taketh all away, but them he cannot take

Apollonius Rhodius (*c.* 295–215 B.C.), a younger contemporary and, for a time, pupil of Callimachus, was the author of a romantic epic, the *Argonautica*, which contains many passages of real beauty, and was destined in later days to inspire Virgil himself. There was also a considerable development of didactic poetry, of which the influence is manifested in Virgil's *Georgics*, but such fragments of them as remain are of interest only to scholars.

Polybius

In prose the most notable achievement was the *History* of Polybius (*c.* 204 – *c.* 122 B.C.), which, opened by a summary of early Roman history, dealt with the story of the decisive struggle between Rome and Carthage and the ensuing half-century of Roman expansion. About a quarter of this valuable record remains; it is notable for its scientific method and breadth of outlook, but its style is uninspiring and unattractive.

Plutarch

There was no renascence of Greek literature ; nevertheless, under the Roman empire two great writers of Greek arose, Plutarch (*c.* A.D. 46–120) and Lucian (*c.* A.D. 120–180). Plutarch, a voluminous and always sensible writer on both philosophical and antiquarian subjects, has become an English classic in virtue of "North's Plutarch," the fascinating series of parallel lives of distinguished Greeks and Romans which, in North's Elizabethan translation, were the main source from which Shakespeare drew his Roman plays. The natural charm of the original is enhanced by the charm of the translator's style.

Lucian

Though a Syrian, Lucian acquired in the study and teaching of rhetoric and philosophy an amazing mastery of the Greek tongue, and wrote on a wide range of subjects ; but his triumph was the development of a new form of prose satire. The medium he invented was the imaginary conversation—*Dialogues of the Dead* or of *the Gods*—making fun of the old fairy tales, laughing at snobberies, vanities, hypocrisies, and pedantries, especially of the pseudo-philosophers. He is the satirist not of vices but of follies, and the English reader can enjoy him thoroughly in the translation by H. W. and F. G. Fowler.

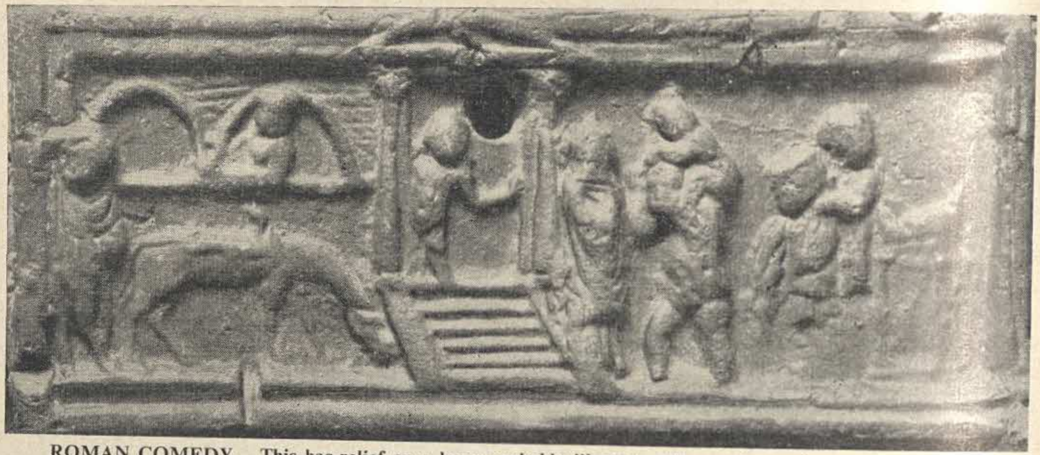
LESSON 7

Beginnings of Latin Literature

A Roman poet, Horace, said that " Captive Greece took her fierce victor captive." This was in many senses a true saying, and it was pre-eminently true in the sphere of literature. Of national Roman literature untouched by foreign influences the only trace to be found is in the rude metre called Saturnian, which the earliest Latin poets used side by side with metres influenced by, or directly borrowed from, the Greeks. The name is derived from the old Roman deity Saturn, in whose honour the ancient ballad songs were sung at harvest time. A form of undeveloped though clear prose is seen in the legal text of the *Twelve Tables*, an early summary of Roman customary law.

Livius Andronicus

The contact with Greek culture began with the cities of Greater Greece in south Italy and Sicily, through the expansion of the Roman domination over central Italy ; it continued through the 3rd century B.C., after which Rome reached out over the whole Hellenistic world. Pyrrhus had been expelled from Italy, Tarentum had been crushed, when the first in



ROMAN COMEDY. This bas-relief on a lamp probably illustrates the mock marriage scene from the "Casina" of Plautus (c. 250–184 B.C.). On the right comes the wedding procession—a woman, a Silenus carrying a Cupid, and in the rear the bride carried by a man in order that she may be lifted over the threshold. A Cupid waits at the top of the steps to receive the bride, and on the left stands the bridegroom with his mule, in preparation for his departure into the country. The comedies of Plautus are distinguished by pungent wit, rapidity of action, and a shrewd knowledge of human nature.

the list of Latin poets appeared ; and he was no Roman, but an educated Greek, Livius Andronicus (d. 204 B.C.), who had been carried into slavery from Tarentum.

Livius Andronicus translated the *Odyssey* into uncouth Saturnians, and went on to write Latin dramas based on or translated from Greek originals, composed on the Greek pattern and in the Greek metres. Mere fragments of his work are all that exist.

Naevius

He was followed by the Roman citizen Naevius (whose first play was produced c. 235 B.C.)—a much greater figure, since he aspired to be a national poet and dared to write a national epic in the native Saturnian metre, with the First Punic War—in which he had served—as his subject. He wrote numerous comedies as well as tragedies, and his national vigour pleased the critical Horace. Naevius possessed a finer literary sense and a finer command of language and style than his predecessor, but the indiscretion with which he satirised the Roman nobles in his plays incurred their hostility, and he was forced to retire to Utica, in Africa, where he died.

ENNIUS (239–169 B.C.) was admired by Cicero and Horace, while even Virgil borrowed lines from him.
Vatican Museum, Rome

Ennius

Naevius was succeeded by Ennius (239–169 B.C.), the acknowledged "father" of Roman poetry. He was born in Calabria and bred in a Hellenic atmosphere, but was as determined as Naevius to be a national poet. A great, if unpolished, poet he undoubtedly was ; this is clear even from the fragments that have survived in quotations from his epic *Annals* of Roman history and his numerous tragedies, which were modelled on the Greek. It is, however, mainly on the *Annals* that his fame rests. It was a chronicle in hexameter verse, often as prosaic as other chronicles, but also often rising to heights of genuine poetry. He dropped the Saturnian line and naturalised the hexameter, which he was the first to introduce, developing it with a skill of which no further witness is needed than the fact that Virgil did not scruple to borrow from him occasionally noble lines and phrases, and even episodes.

Plautus and the Roman Comedy

These early poets, each in his own way, were influenced by the great Greek masters, and accepted their poetic models. Roman tragedy never got beyond the stage at which they left it ; it never became popular, and, though Roman tragedians enjoyed critical applause, none of their works survived the centuries. But while Naevius and Ennius were writing, the Roman comedy, from which all modern comedy is derived, was being created by Plautus (c. 250–184 B.C.). Even of Ennius nothing more remains than titles, stray lines, and fragments ; but for us Roman poetical literature begins with Plautus, a score of whose comedies survive.

The Plautian, and consequently the Roman, comedy derived from the Greek no less than the Roman tragedy, but from Menander and his comedy of manners, not from Aristophanes ; and it flourished on Roman soil as Greek tragedy did not. There are very considerable fragments of Menander himself, but these were unknown when comedy was revived in the 16th century, and it drew not on him directly but on his Latin imitators.

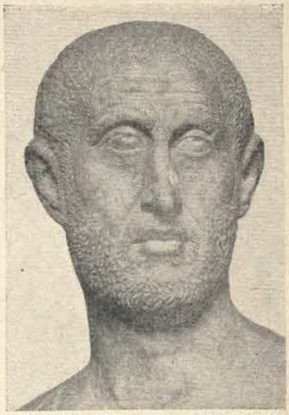
Plautus was born in Umbria. Tradition says he began his Roman stage connexion as a carpenter. However he picked up his education, he acquired a mastery of perfect idiomatic Latin. He naturalised the Greek comedy as Ennius naturalised the Greek hexameter, and gave it the robust and spontaneous Roman flavour of his own genius. His plots were Greek and his characters Greek, with Greek manners, Greek names, and Greek dresses, a feature which gave the comedies of this style the name " palliata " (Greek-robed), in distinction from the " togata," which sought to be Roman throughout. Plautus, however, did not attempt to depart from the convention which imposed Greek as the standard of taste, even though it might be suggested that his characters were Romans masquerading as Greeks.

THE OLD RETAINER. One of the favourite stock figures represented in Roman comedy was the trusted elderly slave, for ever aghast at his young master's misbehaviour. He is grotesquely presented in this statuette.
British Museum

Plautus had an almost Shakespearean capacity for the invention of new words. He covered the whole range of the later Greek comedy in the brilliant burlesque of the *Amphitruo*, the romanticism of the *Rudens*, the sentiment of the *Captivi*, the lively farce of the *Menaechmi*—from which Shakespeare borrowed the plot for *The Comedy of Errors*, and Molière the character of Harpagon. His value lies in his great humour and grasp of character and in the amazing fertility of his imagination. His immediate successor was Caecilius Statius (of Gallic birth), who was greatly esteemed in his own day, and by the best of the later Roman critics ; but none of his work remains.

Terence

Then Roman comedy reached its climax in the brief but glittering career of Terence (*c.* 195–159 B.C.), the second of the Roman progenitors of modern comedy. He was a Carthaginian by birth. His youthful genius won him admission to intimacy with the younger Scipio Africanus, who was the centre of the most cultured circle in Rome. Terence perfected the Hellenism of his art and the Latinity of his style. His success was astounding ; but he died some seven years after producing his first play, the *Andria*, taken from Menander. The six plays that survive were perhaps all that he wrote, four of them being from Menander. As a creative artist he ranks below Plautus ; but as a stylist he was unmatched, and some of his phrases—for example, " I am a man ; nothing pertaining to man is alien to me," are immortal. Others have been so often quoted that they have become clichés : " Hence those tears," " Fortune favours the brave," " While there is life there is hope." We have no record of any writer of comedies after Plautus and Terence worthy to rank with either of them. Moreover, the Terentian comedy was in its turn displaced—at least in popularity—by a less refined form of farce known as the " mime."



TERENCE (c. 195–159 B.C.), in whom the Roman comedy reached its climax.
Capitoline Museum, Rome

Lucilius

All the authors mentioned so far derived their inspiration from Greece, but shortly after the death of Terence the Scipionic circle was joined by Lucilius (*c.* 180–103 B.C.), the father of an essentially Roman literary form, the satire. " The satire," said the rhetorician Quintilian, " is all our own." It owed nothing to the Greek. It had no laws, but was specifically Roman in its bold independence of tone.

Its name, *satura*, means miscellany (originally a dish of various fruits), and the work was a miscellaneous commentary on things at large in any convenient form. Lucilius used it so that it became the foundation of what we classify as satire—from Horace to Juvenal and from Skelton to Swift, and their successors. Lucilius specialised in satire and the acrid criticism of life's absurdities and vices. Of his voluminous output, fairly copious fragments survive. He could be mirthful when he chose ; he certainly was, on occasion, savage in his mockery and never more so than in his denunciation of any form of affectation.

LESSON 8

Masters of Latin Prose

Roman literature was born, as previously stated, in its most national form in the 3rd century B.C., era of the long struggle with Carthage—which, however, brought Rome into direct contact with the much more advanced culture of Greater Hellas. The Greek ideals of political freedom were congenial to the old Roman spirit, and were a decisive force in establishing the ascendancy of Greek literature in Rome. Though eagerly absorbing Hellenic ideas, in the 2nd century B.C. there arose in Rome a literary circle that aspired to do for Rome what the ancient Greek writers had done for Athens. This national culture developed under the influence of the Scipionic circle, still cultivating the Grecian forms, but aiming at preserving the purity of the Latin language.

The younger Scipio was not yet the famous conqueror and leading citizen of Rome, but a young man of about twenty, obviously destined to a great career, when he and his friend Laelius admitted Terence, who had just produced the *Andria*, to their intimacy. Lucilius was perhaps not old enough to have added his gaiety and originality to the group till after Terence's death, *c.* 159 B.C. Polybius, the Greek historian, and Panaetius, the Greek Stoic philosopher, who attracted enormous audiences to his lectures in Rome, were also members of the Scipionic circle.

Scipio later became occupied in war and politics, and was assassinated at the beginning of the Gracchian revolution in 129 B.C. In the turmoil of the next fifty years, ending with the Sullan dictatorship (82 B.C.), no other lasting literary reputation was made ; but at the close of this period Cicero was already noted as a pleader in the law courts, Julius Caesar was serving in the east on his first campaign, and Lucretius (*see* Lesson 9) was a boy of fifteen or so.

Caesar

Caesar and Cicero perfected in Latin the art of prose-writing—not the several literary arts which are expressed in prose. Caesar (102–44 B.C.) was a brilliant orator—second only to Cicero—but none of his speeches has survived. When he chose to write in his leisure moments the story of his own conquest of Gaul, he made his *Commentaries* the most perfect work of the kind that exists, not excepting even Xenophon's *Anabasis*. He writes always with complete detachment, and of himself in the third person. He tells vividly, with no exaggerations or embroideries, what Caesar did, how it was done, and—if necessary—why he did it, in the fewest possible words, with no circumlocutions, no superfluous adjectives, no irrelevancies and no fine phrases, yet with perfect lucidity, mastery of language, and dignity of style. He is not a historian in the sense of one collecting, ordering, and co-ordinating the records of the past so that they have a significance for the present ; he is writing down the history that he is himself making, and is concerned only with that one particular branch of the historian's art in which he has never been surpassed.

Doubtless the Scipionic circle had set a high standard of pure Latin, which was carefully preserved in political oratory. Eloquence in those days of revolution and faction was a mighty force. It was in the pursuit of oratory that both Caesar and Cicero learnt the clarity of expression and use of the right word which they turned to such excellent account in their prose ; and Caesar's recorded *obiter dicta* show that he was a very acute literary critic. He, however, was a born man of action ; the *Commentaries* were only a by-product of his almost universal genius.

MARCUS TULLIUS CICERO (106–43 B.C.). Cicero entered politics and became a consul in 63 B.C. After the death of Caesar he thundered against Antony, and for this he was slain.

Apsley House Coll., permission of Duke of Wellington

Unlike Caesar, Cicero (106–43 B.C.) was a born man of letters, though he conceived himself to be a born statesman. He tried to play in a revolutionary world a part demanding much harder—and perhaps baser—metal than he was made of, and was finally crushed in the process. It is as essayist and writer of letters that he is particularly valuable to us, and in the fact that his great prose has had an influence on writers of the western world.

Cicero

Cicero's works fall into three sections : speeches, treatises, and private correspondence. Several volumes of each of these have been preserved. The earliest of the speeches show only the rising pleader in the law courts. The great orator, the equal of any predecessor except Demosthenes, is first revealed in the indictment of Verres, the corrupt and tyrannical governor of Sicily (70 B.C.).

For the next ten years Cicero was the recognized champion of the Pompeian party, the panegyrist of Pompey (in the speech *De Lege Manilia*), the saviour of Rome from the conspiracy of Catiline. Then his political influence, never quite so great as he himself imagined, waned, since he had in fact lost grip of the political situation. He still made great speeches, but with a loss of quality because he was no longer sure of himself. He then found consolation in philosophic and literary pursuits. Even this failed him in the Civil War. But Caesar's triumph brought an unexpected promise of peace ; his literary as opposed to his political activities culminated in the last year of Caesar's life. After Caesar's murder there was chaos. Cicero was cajoled into believing himself to be the leader of the republicans, and delivered or published the series of diatribes—famous speeches, though perhaps below his own highest level—against Antony which are known as the *Philippics*. He paid the penalty for these with his life in the great proscription which followed.

Cicero's orations are not only brilliant speeches ; they are great literature. By themselves, however, they would not have given him the position which is his as one of the supreme moulders of literary form. Nor would his private *Letters* have done so, though but for them it may be doubted whether letter-writing would ever have become a branch of literary art, an art in which the sense of spontaneity is essential. The post-medieval valuation of him rested upon his treatises, and their influence owed more to their artistry than to their substance. They cover a wide range of topics : *Of Oratory*, and the rest dealing with that subject, in which he was of course a supreme authority, are masterpieces ; *Of the Commonwealth* and *Of Laws* treat of the principles of politics ; *Of Duties* was an adaptation of the book on Stoic philosophy written nearly a century before by Panaetius ; *Of the Nature of the Gods* and others deal with ethics and philosophy ; *Of Friendship* and *Of Old Age* are studies in which many readers still find charm. Through the attractiveness of his handling, his books made a conventional popular philosophy ; so that though he was not following but creating the convention, a later age finds him conventional, whereas intervening ages almost raised him to the rank of a prophet.

CICERO'S VILLA. This comic study of a mendicant musician was one of the coloured mosaics on the wall of Cicero's house at Pompeii, a Roman pleasure resort.
National Museum, Naples

LESSON 9

The Augustan Poets and their Forerunners

THE Augustan age of Roman literature is confined to a period of between fifty and sixty years, beginning with the appearance of Virgil's *Eclogues* in 38 B.C. and ending with the death of Ovid in A.D. 17, in the eighth year of his exile from Rome and the fourth after the death of Augustus himself. Lucretius and Catullus were its great precursors. During its course Roman poetry reached its zenith, and the canons of Roman poetry were fixed ; it is only in satire that anything which could be called development can be found subsequently.

Lucretius

The great age of Roman poetry was inaugurated by Lucretius (*c.* 98–55 B.C.) with a poem which is itself unique in its combination of scientific materialism with imaginative power. Some ten years younger than Cicero, Lucretius, though he has never been popular or widely read, has claims in the view of some critics to be regarded as Rome's greatest poet. His only work is a scientific exposition in hexameter verse, *On the Nature of Things* (*De Rerum Natura*), a poem in six books. In this he expounds the Epicurean theory (as interpreted by himself) of materialism, of the physical constitution of the universe, the inexorable reign of law, and the annihilation of human personality with the dissolution of the body at death ; finding in this a happy consummation—a sleep, as it were, from which no awakening is to be feared.

Religious belief he denounced as the source of man's enslavement and misery. With an amazing imaginative power and precision he anticipates and propounds theories which after nearly two thousand years were postulated by scientists, notably the atomic theory and evolution. In his hands the Latin hexameter attained a majesty which corresponds to that of Milton's blank verse, while the purity of his Latin matches that of Caesar.

LUCRETIUS (98–55 B.C.), poet and scientist.

His poem apparently had no success in the Roman world, but in modern times his claims to greatness have met with adequate recognition, and his place in the front rank, as perhaps the most original figure in Roman literature, is no longer in dispute.

Catullus

In surprising contrast with Lucretius is Rome's first and greatest lyrist, Catullus (*c.* 84–*c.* 54 B.C.), "tenderest of Roman poets," as Tennyson named him. His fire and passion, always virile, are quite as much in evidence as his tenderness ; he is a born singer, a consummate artist. Never was lover more ardent till his mistress proved false ; never were verses daintier than those he addressed to her—or more merciless than those in which he would later denounce her falsity.

In their mastery of verbal music the *Lesbia* poems stand at the head of the lovely lyrical poems of passion of the ages. In them Catullus chronicles his heart's devotion to "Lesbia," sister of Cicero's arch-enemy Clodius. When she is deserting him we have : "Such shames the more compel the lover's love" ; and then :

I hate her and I love her ; wherefore so ?
I know not, but the rending pang I know.

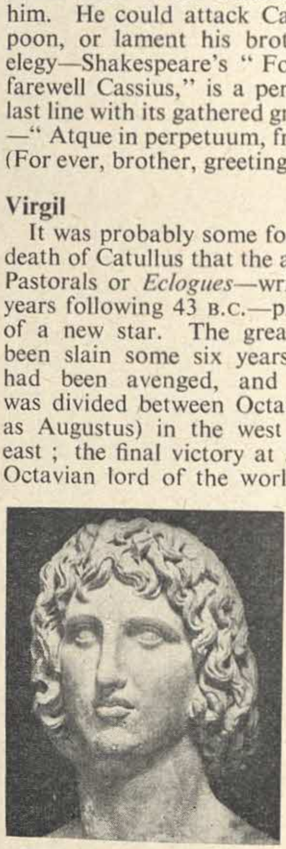
When he hates and scorns, his lash stings like Dryden's : when his delight in the sights and sounds of nature moves him, as it often does, his touch is exquisite. His metrical experiments are often brilliantly successful, preparing the way for Horace, his only rival in that field.

Alexandrinism colours his longer poems—such as the *Epithalamia*, *Peleus and Thetis*, and *Attis*. Well acquainted with Alexandrian technique and with the later Greek authors, Catullus found most of his material in the life around him. He could attack Caesar in a bitter lampoon, or lament his brother in the beautiful elegy—Shakespeare's " For ever and for ever, farewell Cassius," is a perfect equivalent of its last line with its gathered grieving of final parting —" Atque in perpetuum, frater, ave atque vale " (For ever, brother, greeting and farewell).

Virgil

It was probably some fourteen years after the death of Catullus that the appearance of Virgil's Pastorals or *Eclogues*—written during the four years following 43 B.C.—proclaimed the arrival of a new star. The great Julius Caesar had been slain some six years before ; his death had been avenged, and the Roman world was divided between Octavian (not yet known as Augustus) in the west and Antony in the east ; the final victory at Actium, which made Octavian lord of the world, did not come till seven years later, but in Italy he was already undisputed master, and was setting about the restoration of order. Already, too, Maecenas, bountiful lover of all artistry and artists in the Augustan age—the age of which Virgil was to be poet laureate—was his chosen counsellor.

Virgil, like Cicero, created a convention which permeated men's minds for eighteen centuries. Both paid the same penalty. The reverence and admiration for their works which culminated in the 18th century, perished in the 19th, after the upheaval of the French Revolution and the general anarchy of taste which followed. Criticism has now returned to the appreciative view.



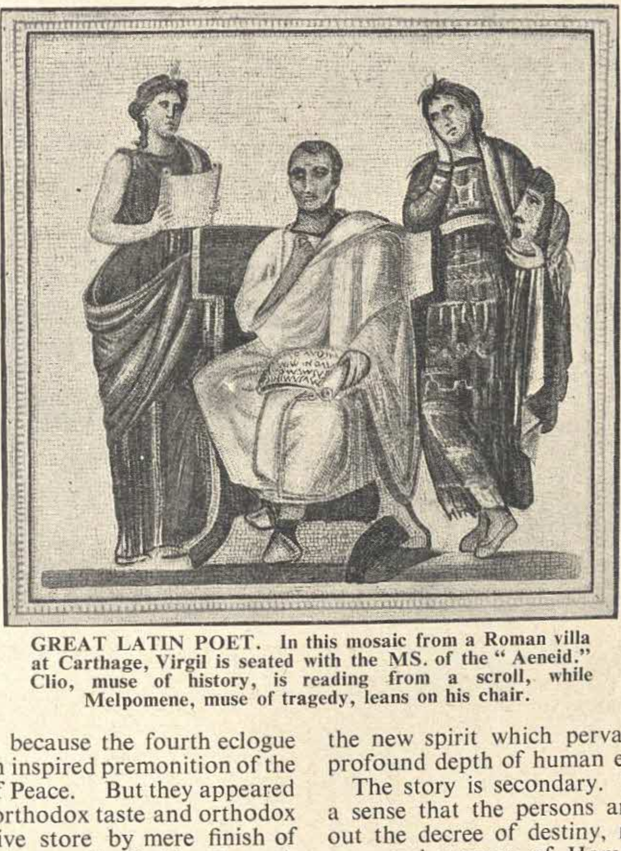
VIRGIL (70–19 B.C.) died at the dawn of the great Augustan era.

Capitoline Museum, Rome

Publius Vergilius Maro (70–19 B.C.) was of what one might call yeoman family, born near Mantua ; but his father managed to give him the best education that Italy could provide His patrimony was confiscated during the Civil War but thanks to the patronage of

Maecenas he was able to devote himself to literature. His work falls into three divisions: the *Eclogues*, written in imitation of Theocritus, which appeared when he was just past thirty; the *Georgics*, or Art of Husbandry, dealing with a real, not an imaginary, country life (doubtless suggested by Hesiod), some ten years later; and—in the remaining ten years of his life—the *Aeneid*, the epic centred upon the figure of Aeneas, the mythological progenitor of the Roman people and more particularly of the imperial Julian family.

In the *Eclogues*, though Virgil failed to attain the full excellence of his model, Theocritus, the poems have the essential quality of charm. They at once gave him rank as the leading poet of the day, though nearly ten years elapsed before his next work appeared. In the Middle Ages they acquired a spurious reputation because the fourth eclogue was interpreted as an inspired premonition of the birth of the Prince of Peace. But they appeared at a moment when orthodox taste and orthodox criticism set excessive store by mere finish of workmanship, and that quality in Virgil's work was convincing enough to ensure his immediate recognition. Charm and finished workmanship together gave him permanently no more than the second place among pastoral poets; but to the mind rightly attuned there is something more, even in the *Eclogues*, already discernible—a hint of that emotion of humanity which was Virgil's most personal gift to the world.



GREAT LATIN POET. In this mosaic from a Roman villa at Carthage, Virgil is seated with the MS. of the "Aeneid." Clio, muse of history, is reading from a scroll, while Melpomene, muse of tragedy, leans on his chair.

The writing of the *Georgics* was pressed upon him with the definite purpose of reviving Italian agriculture. As with Hesiod's *Works and Days*, its aim was instruction; but in the execution Virgil's own love of nature counted for more than his precepts; and, as with Wordsworth, his deep human emotion, closely interwoven with his love of nature, raised the whole poem to a plane altogether higher than that of the *Eclogues*, while not only fulfilling but decisively excelling their promise of finished workmanship and technical development. As a work of art the *Georgics* have been pronounced by some great critics to be almost flawless.

On the other hand, the *Aeneid* is a great work of art, but it could not be flawless. Virgil was urged by Augustus and Maecenas to undertake the writing of the great Roman epic which should be to a Rome much in need of a regeneration what the *Iliad* and *Odyssey* had been to Hellas, the expression of the essential spirit of Rome which was the source of her grandeur—the epic of her heroic origin, the legend of Aeneas. The result was not a Homeric epic—though it used the Homeric machinery—but a poem which is the eternal expression of the Roman ideals, of duty, of character, of patriotism, of destiny; and a poem which was not only national but universal in the new spirit which pervaded it, Virgil's own profound depth of human emotion.

The story is secondary. Inevitably there is a sense that the persons are puppets carrying out the decree of destiny, rather than the live men and women of Homer; yet even here Virgil has succeeded in making of Dido one of the great tragic figures, and of Camilla a maiden not unworthy to be named beside Nausicaa. The unrealities entailed by the epic convention may be drawbacks to the modern reader, but were not so to a Roman audience, and to a Roman the poet's love for the fatherland and for the national traditions was a passionate inspiration, perhaps most of all in the vision of Roman heroes in Book VI and the gathering of the Italians in Book VII. The story of the fall of Troy is magnificently told by Aeneas in Book II; and among many dramatic passages the picture there drawn of Helen stealing in terror through the deserted palace is an unforgettable work of supreme art.

"The sense of tears in mortal things" is Matthew Arnold's rendering of "the Virgilian cry," the new note which was Virgil's supreme gift. Not the terror of the tragedians, but the common underlying pathos of life, " the heavy and the weary weight of all this unintelligible world," the mystery of sorrow whereof individual sorrows are echoes—that is what whispers in the *Eclogues*, murmurs through the *Georgics*, vibrates from end to end of the *Aeneid.* And that is the reason why Virgil—the one pagan whom the Christian Church victorious acknowledged almost as an inspired prophet —stands as the link between the pagan and the Christian worlds.

Horace

While Virgil stands supreme among the Augustans, Horace (Quintus Horatius Flaccus, 65–8 B.C.) is the most familiar Latin author to modern readers. Consciously or unconsciously, Horatian quotations or allusions crop up everywhere. In Shakespeare's day Ovid was more familiar, because parts of his poems were the Latin text-books used by all schoolmasters, and in the selections Ovid, as a prince of story-tellers, wrote about things that stick in boys' heads. But Horace is the poet not of active and emotional youth, but of middle age; he is, let us say, of all poets the most companionable—never uncomfortably serious, though almost always with an undercurrent of seriousness.

It is good, he says, to enjoy life on your Sabine farm ; to watch the spring breaking, frosts yielding to its balmy breath ; to humour pretty Lalage and Chloe—Horace was a bachelor—to gather rosebuds while we may ; to honour the just and steadfast man and cherish the innocence of girlhood and boyhood ; to delight in the congenial society of the wise, the witty and the cultured, in good books and good stories ; to show a proper respect for religion ; to seek in all things the golden mean with placid good taste ; to shun like poison the crude, the extravagant, and the vulgar ; to love your friends and laugh at your enemies ; to be content with plain living (not too plain) and high thinking (not too high) ; to take life as it comes without worrying, though with an ever-present consciousness that, after all, all is vanity :

> Ah me ! the fleeting years, old friend,
> Are ever slipping, slipping past ;
> Not all our piety can stay
> The creeping wrinkles, locks gone grey ;
> Old age, insistent, grips us fast,
> And Death still conquers at the end.

Horace is the prince of those poets who never soar in a rarefied atmosphere or plumb the depths, who are always good-humoured, who are aware of their own limitations and content to do what they do perfectly without attempting to do what, for them, is impossible. Horace would have laughed at anyone who set him on the same plane as Virgil. He is the high priest of the Golden Mean, who invests common sense with charm, platitude with essential vitality, and the commonplace with novelty. With him the thought that is sound but not profound acquires dignity. He says what we all think we think ; he makes us plume ourselves on our own cleverness in having thought it, and grateful to him for having put it so neatly. When other people repeat the same ideas in their own words, they only inspire a scornful impatience. The difference is due to his consummate craftsmanship.

Horace did not suffer from the Alexandrian illusion that craftsmanship is all in all—though he was heavily indebted to that school, but he skilfully avoided its excesses ; neither did he cherish the other illusion that nothing is needed to make a poet but the impulse and the sensitive temperament. His, in practice as in precept, was the infinite capacity for taking pains which he shared with Virgil. The ease of his verse is the outcome not of intuition but of elaboration. The perfect phrase which seems so spontaneous and inevitable is born of the most assiduous selection. The Greek metres have been delicately adjusted to a less mellifluous language. Perhaps they have not the same richness as those of Catullus, who had led the way; yet the fact that they are more laboured does not immediately strike one, though the consummate skill expended on them is sufficiently proved by the other fact that, apart from the work of those two writers, Latin is practically devoid of lyrics.

HORACE (65–8 B.C.), best known of all Roman poets.

In the lyrics, Horace, to use his own words, carved himself a memorial outlasting bronze ; the three books of the Odes to which he referred were written while Virgil (who had himself introduced Horace to Maecenas) was writing the *Aeneid.* But there is another form of poetry in which Horace was only less distinguished than in the lyric—that adopted for the Satires and Epistles, in which he developed what might be called the conversational hexameter. The first book of the Satires was written in his early bohemian days. Though it includes an immortal description of his sufferings at the hands of an intolerable bore, and of the friend who basely deserted him in the hour of his agony, the satire generally is cruder and coarser than in the second book.

The poet of the middle-aged was himself past forty when all his best work was written ; the later Satires have the mellow geniality of the Odes, which becomes still more marked in the Epistles. These are letters in hexameter verse addressed to friends on every variety of subject, from invitations to dinner to the advice to two young friends named Piso. This work (known as *The Art of Poetry*) was accepted for centuries as the final criterion of sound criticism and a handbook of poetic compositions.

Tibullus and Propertius

Horace died at fifty-seven, twelve years after Virgil. Tibullus (*c.* 53–18 B.C.) and Propertius (*c.* 49–16 B.C.), younger men, both died before him. Both occupied themselves with writing not lyrics but serious love poems in elegiac metre, which they brought to a high pitch of perfection, following the example set by the soldier-poet Gallus (d. 26 B.C.), whose brilliant career was shattered by his reckless ambition. His poems have perished. Those of Tibullus reveal an attractive character ; they are limited in range, but are distinguished by tenderness, sincerity, and polished versification.

Propertius is the poet of passionate youth. He flamed into poetry in his early twenties ; his first volume, mainly of love poems addressed to his mistress Cynthia, took Rome by storm. In his later books he never recovered that first ecstasy of youth. He was the victim of a certain morbidity born of a premonition of early death, and, in fact, he did die young. But he did not confine himself to erotic poetry, and in his last volume he showed qualities in some respects higher than even those of the first ; while the last poem of all was a beautiful elegy on a Roman matron, Cornelia, who had in her own person realized the highest ideal of that very noble type.

Ovid

Publius Ovidius Naso (43 B.C.–A.D. 17) closes the list of the Augustan poets. In some ways he was perhaps the most astonishing of the whole series. Educated for the Bar—a fact which left its mark on his poetry—he soon turned to literature. He summed himself up in a line which he put in the mouth of his Medea—" I see the right, approve—and choose the wrong." Whatever he touched, he handled brilliantly ; fine craftsmanship marks his comparatively innocuous first work, *Poems of Love*, and his anything but innocuous *Art of Making Love*, which proved his undoing, as its wantonness earned his decree of expulsion from Rome to the Black Sea coast.

OVID (43 B.C.–A.D. 17), master of metrical form and poet of love.

In the story-telling of his Book of Days (*Fasti*) and the mythological legends of transformations (*Metamorphoses*) mostly with an amatory motive—in which work he used the heroic hexameter instead of the elegiac couplet—and even in the ignominious wailings over the miseries of exile amidst barbaric surroundings in the last eight years of his life (the *Tristia*), he was inordinately clever, the supreme artist. He was witty, fascinating, and steeped in culture, but ethically unmoral and cynical. He gave to the elegiac couplet such a finish of his own that he seems to have made it impossible for anyone after him either to emulate or to depart from his model ; for he had no imitators and no successor.

LESSON 10

Great Latin Historians

BEFORE Julius Caesar composed the record of his Gallic campaigns, Latin historians can be regarded only as antiquarians or compilers of annals, even when they were dealing with contemporary history. They collected data for future historians, but they left no surviving works of literary value. Then Caesar wrote what was in its own field a masterpiece. Like Caesar, the three historians dealt with in this Lesson were literary artists.

Sallust

The first, Gaius Sallustius Crispus (86–35 B.C.), was a younger contemporary of Caesar ; the second, Titus Livius (59 B.C.–A.D.17), was the one great prose writer of the Augustan period ; the third, Cornelius Tacitus (*c.* 54–*c.* 119), was born not less than forty years after the death of Augustus, and belongs to the post-Augustan or " silver " age of Latin literature.

Sallust was twenty-three in the year when Cicero, at the height of his fame, was consul in Rome and broke Catiline's conspiracy (63 B.C.). He attached himself to Caesar's following, was left by him as governor of Numidia after the defeat of the Pompeians, and after Caesar's murder spent the remaining ten years of his life in leisured and wealthy retirement, writing the works on which his fame rests : the stories of Catiline, which had been enacted under his own eyes ; of the Jugurthine war, which had ended some twenty years before he was born ; and—his main work, of which, however, only fragments remain—a history of the ten years following Sulla's death, when he himself was a boy. Sallust deliberately made

Thucydides his model, but the resemblance is superficial ; his mind was of a different order. Like Thucydides, he is not always easy reading, his style is occasionally cramped by excessive conciseness. His moral digressions strike an unreal note, but he had the gift of conveying atmosphere and treated a subject rather than a period of time. He knew his Rome and his Romans ; he knew the country (and the peoples) in which his *Jurgurthine War* was staged ; he discarded—as Thucydides did not—the fetters of the regular annalist ; but he shows neither the intellectual penetration nor the moral force of his model. On the other hand, his narrative power is unsurpassed, as are his pictorial effects ; the fictitious speeches by which he interprets the policies and plans of his actors—Cato, Caesar, Marius—are admirably in character and intensely dramatic ; and he has given us a gallery of remarkably vivid and incisive portraits.

SALLUST (86–34 B.C.). A historian with superb narrative and dramatic powers and a gift for conveying atmosphere.

Leningrad Museum

Livy

A historian of an entirely different type is Livy. The outstanding figure in Augustan prose, he is also typical of that age in one of its most essential features, its glorification of the Roman ideal of which Virgil was the prophet. He differs from the poet in that he had no enthusiasm for the new imperial system ; his fervour was reserved for the " brave days of old." But the two were united in their admiration for the old Roman character which the one—with Augustus himself—craved to revive through the new system, while the other would have preferred to revive the old republican system as the necessary condition of the revival of character. Livy foresaw, in the growth of luxury, the decline of Roman greatness.

The general agreement between the two writers is, however, very much more significant than the difference.

Livy's ambition was to write a history which should be the everlasting monument of the greatness of Rome, and he spent his whole life—a long one—on the task. He succeeded ; though three-fourths of his work perished, the remaining fourth suffices for his purpose. That portion covers the history of Rome from its legendary foundation by Romulus in 753 B.C. to the destruction of the Macedonian power in 168 B.C., omitting seventy years from 290 to 220 B.C., the ten books dealing with that section having been lost.

Livy was more concerned with the art than with the science of the historian and with essential truth than with meticulous exactness of unessential detail ; with creating a true conception in the large rather than guaranteeing precision in minor matters. Expressly, where decisive information is not available, he prefers the account which appeals to his imagination. He does not, like the dramatist who has chosen a historical theme, deliberately manipulate historical events to suit the exigencies of the drama, but where there is a reasonable doubt he gives himself the benefit of it without over-anxious probings.

He is writing not for the learned or for the vulgar but for humanity ; he is displaying a mighty panorama—one may almost say a pageant—that has to appeal to imagination no less than to erudition. Lucidity and simplicity of statement being primary essentials, his style is modelled on Cicero, though acrid purists of his own day condemned the provincialism of his Latin. He was a scholar whose own life was remote from public affairs, with an inherent attachment to the senatorial tradition, so that modern students of Roman history reproach him for inadequate knowledge of constitutional law and his civilian's lack of insight into things military.

He wrote the epic of Roman history in prose, as Virgil wrote the epic of Roman legend in verse, with a keener appreciation of its poetic than of its informative aspect, and an inadequate appreciation of his own debt to Polybius, who had been so much more thorough and so much less inspiring than himself. But the heroes of old Rome and their deeds, and their worthy foemen, live and are immortalised in his pages. The grandeur of old Rome permeates them. And he has in full measure that sense of dramatic values and the gift of vivid presentation which place him in the front rank. One may say of him, with Quintilian, that in the speeches " he attains to an eloquence almost passing belief."

LIVY (59 B.C.–A.D. 17), who devoted forty years of his life to compiling his great history of Rome, in 142 books.

Tacitus

Tacitus belonged to another and a later age. He was a child during the nightmare of Nero's reign, a grown man through the fifteen woeful years of Domitian's tyranny ; and he wrote the history of the 82 years which passed between the deaths of Augustus and Domitian, whom he obviously believed deliberately to have done to death Agricola, the father-in-law of Tacitus, whom the historian loved and revered above all men.

Of those years he has left a picture painted with such lurid power and such manifest sincerity as entirely to convince the imagination of the world, though reasoned criticism challenges its justice at least in relation to Tiberius, the first successor of Augustus. Tacitus belongs to no school ; it has been said that in his works we " see history by lightning flashes." His style, though in his earliest work it ran approximately on the orthodox Ciceronian lines, very soon became entirely individual, following no one and impossible to imitate ; and in his treatment of his subjects he ignored all conventions.

His first work, produced as a juvenile—probably during the reign of Vespasian—was a dialogue on Oratory : during Domitian's rule, when no historian could breathe freely, he published nothing. Then came two brief but masterly volumes, the biography or panegyric of his father-in-law Agricola, the organizer of the province of Britain—a noble portrait drawn by an enthusiastic admirer of a great man—and the *Germania*, a study of the manners and customs of the German tribes beyond the Rhine frontier.

In these he had already formed the style and method which give him his unique place among historians and were fully developed in the *Histories* and *Annals*, treating respectively the later and the earlier portions of the period from the accession of Tiberius. The major portion of them is lost ; but the history of Tiberius, the study of Nero and his court, and, above all, the Four Emperors' revolution, have the tremendous quality of great tragedy ; the portraits are life-like creations, and the artist's power of suggesting a whole chapter of psychological analysis in a single poignant phrase, as he does continually, has never been surpassed.

TACITUS (c. A.D. 55–c. 119), highly esteemed as a historian both in his life and by modern critics.

Obvious defects as a historian were his faulty strategic and geographical details ; also his prejudices. His power of colouring facts by suggestion is unrivalled. No one would dream of calling his judgements impartial or logically convincing, but they evoke an irresistible impression of his own sincerity ; and the history of that century lives in his pages as vividly as the Athenian story in the pages of Thucydides.

LESSON 11

Seneca to Juvenal

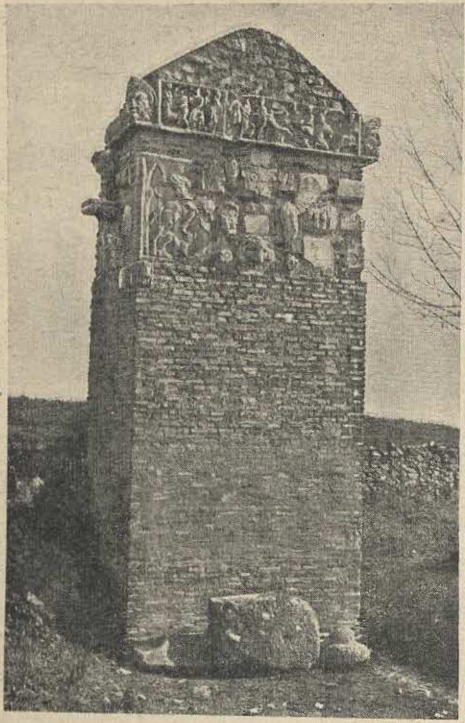
In the century following the deaths of Augustus, Ovid, and Livy, incomparably the greatest Roman literary figure is that of Tacitus, who has been discussed in Lesson 10. The second place is held no less securely by the satirist, Juvenal.

There are in this period several who for varying reasons demand at least our interested attention. The first of these is L. Annaeus Seneca (*c.* 4 B.C.–A.D. 65), a Spaniard who was primarily a moralist, an exponent of the Stoic philosophy, in which the best of the Romans, in the years of which Tacitus wrote the history, sought salvation.

Seneca and Tragedy

As a constructive philosopher Seneca is of no account ; as a preacher he often rises to heights of real eloquence, which so impressed the religious minds of the Middle Ages that a correspondence between the eminent Stoic and St. Paul was forged and accepted as genuine for many centuries. But for the student of literary history his chief importance is that he was the one Latin tragedian whose works survived and were accepted at the Renaissance as the classic model. In comparison with Seneca the great Greek tragic poets had then a negligible following. Tragedy, which flourished among the Greeks, was, in fact, for the Romans an exotic, academically cultivated.

Seneca would seem to have attempted the creation of a literary drama for reading rather than staging. He was not a poet, but he was a considerable rhetorician. His work survived ; and so at the Revival of Letters it was, unfortunately for art's sake, he and not Sophocles who became the authoritative model for tragedy, as did the plays of Plautus and Terence, not of Aristophanes, become the models for comedy to Renaissance playwrights. Because he was a rhetorician, Seneca's method was an



LUCIUS ANNAEUS SENECA (c. 4 B.C.–A.D. 65). Born at Corduba in Spain, he arrived in Rome and was appointed tutor to Nero, and for a time was his minister. He fell into disfavour, however, and was ordered to commit suicide in his villa on the Appian Way. The frieze at top left is reputed to belong to his tomb on that famous road. Seneca is at his best in his writings on morals.

Courtesy of Professor Halbherr

alternation of declamatory speeches and set dialogue conducted in single lines and couplets (technically known as stichomythia). Shakespeare used this method in *Richard III*, but rarely in his later tragedies. The plays themselves were repetitions of the immemorial Greek subjects—Medea, Agamemnon, Hercules, and so on—and were melodrama rather than tragedy, while in the delineation of character they are wholly lacking.

Petronius

A different but lively interest belongs to the *Satyricon* of the intensely clever Petronius (d. A.D. 65). This is a novel or medley, part prose, part verse, depicting low life in south Italy, of which considerable portions survive; it is remarkable for its brilliance and infinite diversity. In this entertaining show the most entertaining item is a real gem of humour, *Trimalchio's Banquet*, the dinner party of Trimalchio, the *nouveau riche*, whose absurdity almost achieves the sublime. Tacitus has left us an incisive portrait of the author as a man of unusual talents who, though at first consul and then provincial governor, preferred to fritter them away in the character of favourite, master of the ceremonies, and arbiter of taste and elegance to the emperor Nero.

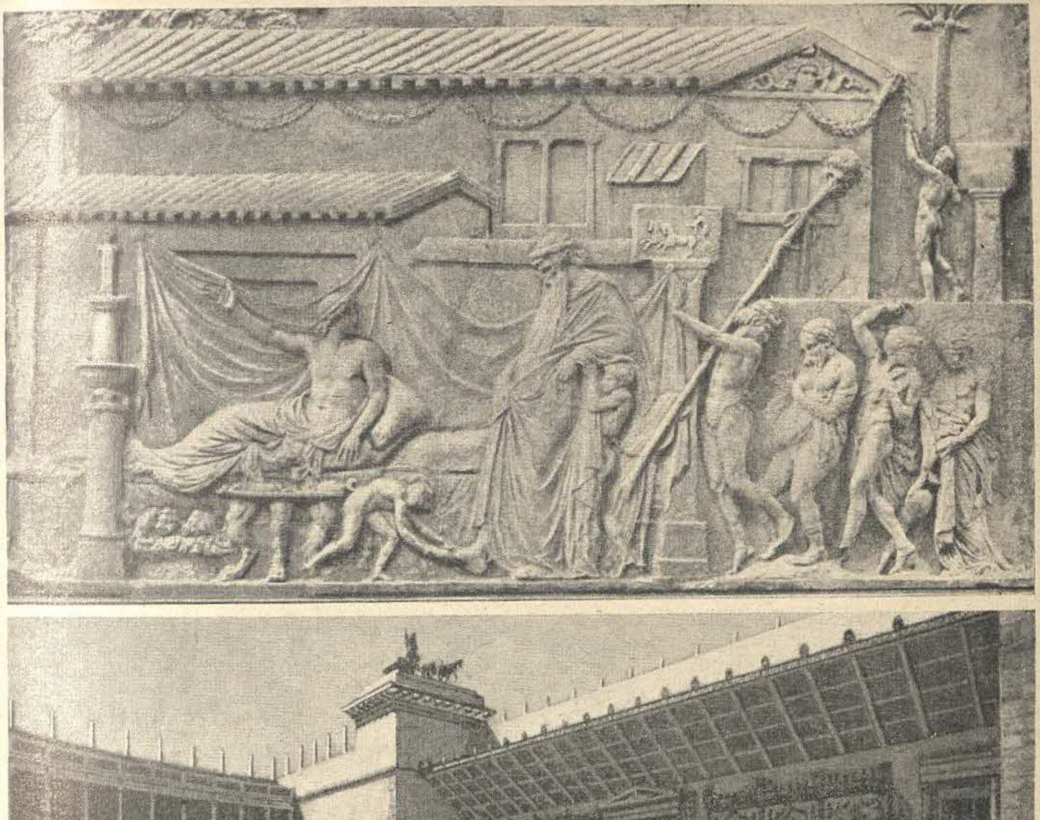
Persius

The satirist Persius (34–62) is a singularly lovable if somewhat paradoxical figure. He was young, high-minded, inexperienced, and very much in earnest. Brought up with his sister in a refined domestic circle by his widowed mother, he was tutored by the Stoic Cornutus, to whom he was deeply attached and who after his early death edited the slender volume of his satires (six in all). His personality is more interesting than his literary product, though he had a high poetic vein. He is extremely difficult to read by reason of an allusive method, the key to which is often hard to discover, and a love of far-fetched phraseology.

Lucan

Seneca's brilliant nephew, Lucan (Marcus Annaeus Lucanus, 39–65), was a schoolfellow of Persius, but had a more meteoric career. He is one of the four post-Virgilian epic poets who for a short time enjoyed a great reputation, and of whose works a substantial proportion survived. Of the four, Lucan was the only one who could be called brilliant. For all of them Virgil was the master; Lucan, however, deserted the epic convention in choosing for his theme in the *Pharsalia* the historic struggle between Pompeius, his nominal hero, and Julius Caesar, his Satan, who usurps the role.

Like his uncle, Lucan was a professed Stoic, who became the intimate companion of Nero, quarrelled with him, involved himself in a conspiracy, denounced his own mother as an accomplice, and, when that proved to be of no avail in saving him, committed suicide, declaiming some lines of his own, describing the bloody death of a soldier. He was theatrical without being dramatic, in his



ROMAN TRAGEDY IN AUGUSTAN TIMES. The marble relief shown in the upper picture represents a visit of Bacchus and his train of Satyrs, come to honour a tragic poet, who is shown on the left, reclining in the open air outside his house. A reconstruction of the famous theatre at Ostia, originally built during the reign of Augustus, is shown in the lower picture. The theatre is seen here as it was in its prime : a rich proscenium with statues and columns, and auditorium rising in two main divisions from a mosaic-paved orchestra. Awnings spread from masts screened the audience when the sun was hot.

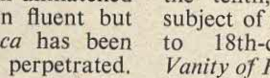
Relief from British Museum ; Theatre after a reconstruction by D'Espouy-Joseph in "Architektonische Einzelheiten" epic as in his life. His characters are well described, but they do not live. He has fine epigrammatic lines and admirable passages, but they are great rhetoric rather than great poetry. His verse is often turgid and artificial.

Silius Italicus and Valerius Flaccus

To be tolerable at all, an epic must at least have some quality of greatness besides mere size. The three epic poets who were seeking ambitiously to maintain the tradition of the close of the 1st century need only the briefest notice. Silius Italicus (25–101), nicknamed "Virgil's ape," dealt at great length and with unmatched dreariness with the Punic Wars in fluent but colourless hexameters ; his *Punica* has been described as the worst epic ever perpetrated. Valerius Flaccus (d. *c.* A.D. 90) tried, not without a certain talent, to put fresh life into the legend of the Argonauts, but left his work incomplete.

Statius

On a higher plane is Statius (*c.* 45–96). In some of the love poems, which occur among his shorter pieces in the volumes called *Silvae*, and in many descriptive passages, there is a real charm, while his verse has richness, refinement, and variety. But in his epic, the *Thebaïs*, which used to be accounted a masterpiece, he is a painter of miniatures attempting fresco ; he lacks the qualities of the epic poet.



APULEIUS. Living in the 2nd century, Lucius Apuleius in his story of "The Golden Ass" preserved a lost Greek romance for posterity. He wrote with a charm which even his queer Latin did not spoil.

From Bernouilli

Martial's Epigrams

The term epigram in classical literature covered almost every kind of short poem (not being a lyric) which was complete in itself; the individual sonnets of modern poets would have been classed as epigrams. Martial's epigrams have given the term its specialised modern meaning of verse in which the essential qualities are conciseness, completeness, polish, wit, and a suggestion of venom, concentrating on a single point. Not that Martial (Marcus Valerius Martialis, *c.* 41–*c.* 104) was invariably venomous ; he could be graceful, genial, even tender ; but these are his main characteristics.

Epigram, so understood, cannot be great poetry, but may be distinguished literature, and Martial's brilliant epigrams were, fittingly enough, the one distinguished literary product of the closing years of the 1st century A.D. In him those years did not rouse the flaming moral indignation of a Tacitus or a Juvenal, but they provided ample opportunity for a wit —and that wit, it may be added, did not hesitate at indecency.

Juvenal's Satires

Martial's epigrams are for the most part personal thrusts at individuals. The satires of Juvenal (Decimus Junius Juvenalis, *c.* 60–140) lash savagely the vices of a society which he paints as utterly corrupt from top to bottom. A moral rage possesses him which precludes the reticences of other moralists, and he is often most repulsive in his stark coarseness.

Three of his sixteen satires stand out from the rest—the first, third, and tenth ; of all three there are admirable translations by Dryden. The first might be called the Prelude to Satire ; the tenth, dealing powerfully with a stock subject of the moralists, is imitated or adapted to 18th-century conditions in Johnson's *Vanity of Human Wishes ;* and the third, a lurid description of Rome as Juvenal (and Tacitus) saw it, is similarly treated in the same author's *London.* There is no fair reason to doubt the genuineness of Juvenal's detestation of vice, or his reverence for the sacredness of innocence, but the calculated grossness of detail which prevails in most of his denunciations is undeniably nauseating. He has none of Horace's urbanity, deriving rather from Lucilius at his fiercest ; but in sheer force and vividness he is unsurpassed.

Apuleius

Juvenal is the last of the great Latin classics, but a word must be said of Apuleius, who, later in the 2nd century, wrote a fantastic novel, *The Golden Ass*, into which he introduced the immortal tale of Cupid and Psyche. His Latin has a strong African flavour and is delightfully rendered in English in the 16th-century translation by William Adlington (Loeb Classical Library).

With Apuleius in Latin, as with his contemporary Lucian in Greek (*see* Lesson 6), this Course in Classical Literature comes to a close.

BOOK LIST

In addition to the books named in various Lessons, the student should become acquainted with *The Oxford Companion to Classical Literature*, and *A Companion to Greek Studies*, ed. L. Whibley, and *A Companion to Latin Studies*, ed. J. E. Sandys (both Cambridge University Press). Gayley's *Classic Myths* (Ginn) and Bullfinch's *Age of Myth and Fable* will enable him to understand the constant allusions which are to be found not only in classic literature but in our own. The general background is given in *The Glory That Was Greece* and *The Grandeur That Was Rome* (Sidgwick), *The Pageant of Greece*, ed. R. W. Livingstone, and *The Mind of Rome*, ed. C. Bailey (both Oxford University Press). *The Oxford Classical Dictionary*, edited by nine front-rank classicists, is an invaluable work of reference on all classical subjects, persons, and problems.

ECONOMICS

F*OR the most part this Course is concerned with the theoretical substance of economic thinking. Light is thrown on the forces that underlie commercial and industrial activity and that govern the size of the national income and the way it is shared ; and on the immediately practical problems of exporting, the price level, and the maintenance of employment. The role of the professional economist in commerce and industry is also explained. For the monetary aspect of Economics, the student is referred to the Course on* MONEY *and* BANKING *in Volume 2.*

35 LESSONS

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LESSON 1

Everybody's Business

ECONOMICS, or political economy as it was once called, has to do with the basic needs of humanity, with the satisfaction of men's demands for food and drink, clothing and shelter, leisure and recreation. It considers how men—and of course women—get their livings, how they earn their incomes and how they spend them. It explains why many things are as they are found to be. Explanation must not be confused with justification. It is all too clear that there are things wrong with the present economic system. But only those who have some acquaintance with the theoretical basis of the system can understand its practical working, and, understanding, can suggest ways and means of making it work more satisfactorily.

From Village to World Economy

One may distinguish three main stages in the economic development of the world. First, the *domestic economy*, the stage when each village was economically self-sufficing. A village, in medieval Europe for example, grew its own food, produced its own raw materials for its houses, clothing and implements, and spun and wove its own clothing. It was dependent on other areas merely for its supply of salt, its iron, and perhaps its millstones.

The second stage is *national economy*. In this period the various districts began to specialise in the products in which they possessed great natural advantages. This specialisation could never be developed to a high stage because the primitive means of communication made the transport of some commodities expensive and of others impossible. A not inconsiderable specialisation, however, was achieved in such commodities as cloth and wool. Thus in the England of the Stuarts and of the first two Georges the Cotswolds were preeminent for wool, while East Anglia, the West Country, and Yorkshire were famous for their cloth. In this stage of economic development internal trade played a more prominent part in the economic life of the country, but international trade, though increasing, remained relatively unimportant. In the case of England, spices from the East and silks and muslins from India accounted for the great bulk of the imports. Raw wool and woollen cloth accounted for the great bulk of the exports.

The industrial revolution—it may be dated from about 1760—ushered in *world economy*. New inventions in industry enabled each district or country to exploit its natural advantages to an infinitely greater extent than ever before, while the revolution in transport by land and water enabled those products to be exchanged on a scale hitherto undreamt of. The extent of the specialisation thus engendered and the interdependence of countries to which it gave rise were completely new factors in the world.

Growth of International Trade

Thus Britain became dependent on foreign countries to an overwhelming extent for her food supplies. In peace-time she imports 75 per cent. of the wheat she consumes, 95 per cent. of her butter, 40 per cent. of the various kinds of meat, and something like 75 per cent. of her cheese. Nor are her industries less dependent on supplies from other countries for the raw materials which they use. One has only to think of the vast quantities of cotton, wool, oil (mineral and vegetable), copper, tin, rubber, etc., imported to realize how soon Britain's industry would be brought to a standstill if it were completely cut off from foreign sources of supply.

And what is true of Britain is also true, although to a somewhat smaller extent, of other countries. In short, foreign trade has assumed vital importance in the life of almost every nation. To realize the truth of this statement, one has only to remember that a quarter of all mechanically propelled vessels are tankers, carrying oil from the few places where it is abundant to the rest of the world. Without this oil, life as it is known to-day would be impossible.

Rise of "Trade Science"

Before the industrial revolution, economics as a science had hardly begun to exist. The social and trade relationships seemed natural, and few men sought to probe and discover the principles underlying them. But the rapid growth of factories, the invention of power-driven machinery, the application of steam, the development of the iron and steel industry, of engineering, and of railways, changed all this. They brought a vast increase in goods, the need for trade, towns that too often were ugly, a decayed countryside, a new class of manufacturers, poor working conditions for women and children in mills and mines, and a disconcerting increase in the population. These things troubled many who sought to find the principles which govern communities in the task of getting and spending.

Adam Smith (1723–90) in his *An Enquiry into the Nature and Causes of the Wealth of Nations*, published in 1776, explained much, and he laid a foundation on which generations of writers have built. But economics is still an inquiry. One has to approach the subject with an inquiring mind, and try to understand why things happen as they do in the process of getting a living, individually and as a community. The way of life has become intensely complicated through the application of scientific discovery and the continued growth of population. The task of studying business and industry from the social angle is difficult. Even the homely loaf of bread embodies something of the labours of hundreds of men and women in various parts of the world ; and the butter or margarine spread upon it comes to the consumer only through the successful co-operation of a host of people in two or three continents. Economics aims at explaining the basis of this co-operation.

LESSON 2

Division of Labour, and Economic Progress

A HUNDRED or so years ago the average income of members of the various classes in England was about one quarter of what it was in 1938, before the Second World War. What was the cause of this fourfold increase of the wealth of the community in the course of a century ? The obvious reply is that it was due to the increase in industrial efficiency. This is true, so far as it goes ; but a more satisfactory answer—because it goes to the root of the matter—is that the increase was due to continuous progress in specialisation, or division of labour, made possible by the advance in technical knowledge and in economic organization. The history of industry can be viewed, indeed, as simply the ever-widening application of the principle of the division of labour.

Jacks of All Trades

To appreciate the full significance of this division of labour or specialisation one should glance at the life of an average worker in the Middle Ages. His work, year in, year out, included the most varied activities. With the aid of his wife he produced his own bread, growing his own wheat and baking his own loaf ; he produced his own drink, growing his own barley and brewing his own ale ; he produced his own meat ; and he spun the wool which he had clipped from his sheep into thread and then wove it into fabric for the clothes which he wore ; he made his own shoes from the hides of his cattle ; and so on.

Nor was this system confined to the Middle Ages. It lingered in parts of Scotland into the 19th century, and in Russia into the 20th. It was, of course, far from efficient, although socially it had its compensations. What could a peasant know about stock breeding or the raising of crops when he had so many other occupations to pursue ? How could he become an expert weaver if he wove only sufficient for the needs of his household ? But with every increase in the division of labour efficiency increased ; more could be produced in the same time and with the same effort. When the workers began to devote themselves to spinning and little else, or to weaving and little else, when agriculturists began to specialise in the production of wool or in stock breeding or in the production of cereals, the way was opened to a vast increase in productivity. For specialisation, quite apart from the advance in technique which it greatly facilitates, greatly increases productivity by subdivision and repetition of tasks.

The increase in the efficiency of individuals resulting from specialisation is no more than the beginning of the story. There are further factors of enormously greater importance. In the first place, the subdivision of tasks which specialisation introduces leads to the introduction of mechanical aids to production and to the application of new processes. Once the manufacture of an article has been broken up into a number of simplified operations the introduction of machinery becomes possible.

The introduction of machinery leads in its turn to the introduction of new processes and an ever-widening application of power. Thus the inventions of the 18th century led to a great increase in the demand for iron. The production of iron being in an extremely unsatisfactory state, inventors, applying themselves to the task of discovering new methods, introduced the processes of puddling and rolling, revolutionised the manufacture of cast iron goods, and devised the steel furnace. These discoveries in their turn led to an urgent need for power, which stimulated Watt and his successors to invent and improve machines to use steam power.

Localisation of Industry

Specialisation leads to the concentration of industries in particular localities. This is due to the fact that the various localities vary enormously in their resources. Thus certain areas in France are eminently suited for the production of wine, South Africa is noted for the extraction of gold, the southern states of the U.S.A. for the production of cotton, Malaya for rubber, Jamaica for bananas, Persia for oil, and so on. In industry various parts of Britain and the U.S.A.—to mention only two leading countries—are eminently suited for manufactures, owing to their possession of cheap sources of power and to their accessibility to raw materials and to markets.

LESSON 3

Specialisation in Production

JUST as it is profitable for the individual to specialise in that kind of work for which his endowments are best suited, so it is profitable for a country to specialise in those industries for which its resources are best suited. It is impossible for any individual, X let us say, to make the most of his capacities or to gain the advantage which specialised training gives him, unless two conditions are present. First, there must be other individuals who are specialising in the production of other things. This is necessary in order that those other people may have a surplus of their products to exchange for the produce of X's activities. For X cannot live on, say, boots. He must exchange the boots he produces beyond his modest requirements for food, clothing, and shelter. Second, in order that this process of exchange should take place there must be an organization—the complexity of which will depend on the degree of specialisation—to co-ordinate the work of the specialists and to effect an orderly exchange of their products.

As it is with individuals so it is with countries. Great Britain, for instance, could utilise to only a very small extent her vast resources of power, her great industrial technique and skill, her magnificent harbours and her unique geographical position, if other countries in their turn had not specialised in the products she requires.

It is difficult to exaggerate the economic importance of international specialisation, or the specialisation of particular regions within a country. It is as important that countries should concentrate on the production of those commodities for the production of which they have special aptitudes, as it is for individuals to cultivate their special aptitudes. There is great need to reduce the trade barriers between nations to their minimum. Every barrier to international trade means less specialisation, less efficient production.

Business Organization

Specialisation, then, is the fundamental principle of the modern economic system. On it are based a vast increase in efficiency and the consequent growth of wealth. But specialisation implies organization, and as it extends organization must become more elaborate. A complex organization of middlemen is necessary to maintain the close harmony which is essential between businesses, the bulk of which confine themselves to the production of a minute part of a commodity. A vast retail system is required to maintain contact between producers and consumers: while dominating the whole economic system is the great financial machine. In the modern age finance is supreme ; mediating between the possessors of surplus wealth and the producers who require capital for productive enterprise, it regulates the flow of capital, directing it into the channels indicated by profit.

It is not difficult to realize how fundamental organization is in the modern world. Take the case of a clerk in the cost office of a manufacturer. He makes his living—that is, he provides himself with a variety of food, with clothes and house room, and a certain amount of comforts and luxuries—by entering figures on sheets and cards. The organization that is implied by this fact—that a man may, in the modern world, exchange the service of writing figures on sheets for a variety of commodities such as tea from India, beef from the Argentine, films from Hollywood, wheat from Canada, wool from Australia, butter and bacon from Denmark, and so on—outruns the limits of the imagination.

Menace of Unemployment

Specialisation brings with it, however, one great danger among lesser ones. Such extraordinarily complex and delicate machinery as makes up the modern economic system is all too easily thrown out of gear, with disastrous consequences. A change in the taste of consumers may plunge an industry into the depth of depression. A change in industrial technique may have similar consequences. A country may raise new tariff barriers, thereby dislocating the industries of other countries. The supreme danger lies in the realm of finance ; for, unless the financial authorities ensure that the rate of investment keeps pace with the rate of saving, a trade depression affecting all industries and producing widespread bankruptcy and unemployment inevitably ensues.

Unfortunately these factors of disturbance have grown with the growth of specialisation. In the first place, the fluctuations in the demand of consumers have been increasing with the increase of wealth. This is due to the fact that the wealthier one becomes, the wider is the range of choice. When one is poor one has to spend the great bulk of income on necessities ; the range of choice is narrow. As income expands there is a wider margin to spend on luxuries such as radio, television, and motor cars. In the realm of luxuries one has a far greater freedom of choice ; one may be buying television sets this year and motor cars next. Hence the wealthier a country grows, the more unstable does its demand become. This is one of the reasons why advertising is carried to such lengths. Some means have to be found for preventing too violent fluctuations in the tastes of consumers, and advertising does to some extent prevent this.

The instability is increased by the extreme rapidity of invention and discovery. It is hard to recall that the motor car was a rarity in the year 1905, that the aeroplane was still a hopeful experiment, that radio and television had still to be developed, that the cinema was in its infancy, that rayon and nylon and, indeed, most of the plastics, were unknown. The chemist and the physicist are transforming industry so quickly that the world is living in a continuous industrial revolution. The methods of manufacture, as well as the products, are changing equally fast. The automatic machine, able to produce, say, nuts or bolts by the million, is being succeeded by the automatic factory able to manufacture and assemble a whole product. Things are produced in anticipation of demand. The more complex trade and industry become, the more difficult is the task of co-ordinating the complex pattern of buying, making, and selling. The more involved the technique of manufacture, the longer the period of preparation that is necessary, so that organizers of businesses have often to plan two or more years ahead. At any time a scientific discovery, an invention, a political crisis, or the activity of a competitor, can make all their planning out of date. Fortunately most plans seem to mature, and there is an increasing productiveness that enables even the rank and file to enjoy a variety of things that would have been unbelievable only fifty years ago. But it is well to remember always that the economic machine can work only while those in charge of finance, trade, and manufacture continue to have confidence that the plans will continue to fructify, and that they will still be able to sell their goods at a profit.

LESSON 4

The Middleman's Part in Industry

In order that the vast potentialities of specialisation should be realized, organization of the various parts is essential. In this organization there are three features of outstanding importance ; the middleman, the financial organization, and the joint-stock company.

The middleman is often regarded by the public with suspicion as an intruder who forces himself into strategical positions in order to extract toll from the producer or the consumer or both. That the middleman sometimes exacts an excess of profit cannot be denied. But this does not imply that his services are not essential. In fact, on him devolve two highly important functions. In the first place, his work consists in keeping the various specialised producers in step with one another. That is to say, he acts as a link between the stages in the productive process. In the second place, he directs production into the channels desired by consumers. That is to say, he acts as a link between producers and consumers. In order to appreciate the nature of these services of the middleman, one cannot do better than observe how the necessity for him arose, as the economic system became ever more and more complex.

Guild System

In medieval times, when industry was organized in guilds, the middleman did not exist. The craftsman in the glovers' guild, for example, bought his material direct from the tanner, worked it up with his own hands, and sold the gloves which he produced directly to the consumers in the shop in front of his parlour. This guild system was possible because of the narrow extent of the market. There was a guild of tanners and a guild of glovers in almost every town. Hence the producer could maintain personal contact with the man who supplied him with his raw materials, and with his fellow townsman who bought his gloves.

Concentration of Industry

As soon as industries began to be concentrated in particular localities the guild system broke down. When, for example, England began to export woollen cloth—the staple export of the country until the industrial revolution — the producer found it impossible to keep in touch with the varied needs and fluctuating demands of foreign countries. As a consequence, the great merchants with a specialised knowledge of foreign demand in their particular line arose to dominate production. The weaver of woollen cloth, no longer able to ascertain directly the needs of the consumers of his product, now produced according to the order of the merchant. As with the finished product, so with the raw material. The production of wool became more and more concentrated in areas particularly suited for sheep grazing, such as the Cotswolds. This concentration in its turn gave rise to a guild of merchants whose function it was to distribute the wool to the thousands of small producers.

As specialisation becomes more intensive, co-ordination becomes increasingly important. Just as the shopkeeper acts as a vital link between consumer and producer, so the merchant acts as a vital link between producers in various stages of production. A tailor, for instance, does not buy his cloth direct from the cloth manufacturer but from the cloth merchant. He does this because the merchant can offer him facilities and services which are worth the price charged for them, i.e. the merchant's profit. For the merchant has a specialised knowledge of cloths and of the quarters in which they can be purchased, which the tailor has not the time, even if he has the ability, to acquire. Moreover, the merchant, by keeping a stock on hand—again involving the work of a specialist—offers the further facilities of immediate delivery and a wide selection. Thus the middleman saves the producer the time and money which it would cost him to keep in touch with the grower of his raw material on the one hand, and with the consumer of his product on the other. He also saves him the expense of storing the raw material until he wants it, or of carrying and exhibiting stocks of manufactured goods until a customer chooses to come along and buy them. In rendering these services the middleman performs what can be regarded as his most characteristic function, the forecasting of demand.

For the foregoing reasons the middleman may be regarded as the hub of the economic system.

LESSON 5

Savings and their Function

If the middleman were able first to ascertain the requirements of his customers and then to pass on the information to the producers, his job would be a fairly simple one. But this he cannot do because production takes time.

It is sufficiently obvious that the work that most people are performing to-day will bring no benefit to the ultimate consumer until a considerable period has elapsed. In this period many things may happen which will alter the value of the work. The demand for the commodity one is helping to produce may fall off, either because people prefer to spend their money in other ways or because a more attractive variety of this particular commodity has been put on the market by a competitor. An invention may result in the production of some rival commodity or in the introduction of more efficient methods of production. Hence the work of forecasting demand is of supreme importance, perhaps the most vital function in the economic world. The role of the middleman is, however, only one aspect of the complex system of persons and institutions engaged in the task of forecasting; the financial organization plays an indispensable part.

Importance of Finance

In order that the industrial machine should turn out the kinds and the quantity of the commodities that consumers demand, it is necessary that the capital of the community should be in the right place at the right time; that is to say, the various producers must be equipped with adequate and suitable plant (fixed capital) and with adequate funds (circulating capital) with which to pay for their raw material, their labour, and other requisites. The provision of capital involves saving, and saving is effected here and there by numerous people in relatively small amounts. Hence the need arises for gathering these savings together and for distributing them to the places in which the demand for them is greatest. This function is performed by the financial organization, which is the second salient feature of the economic system.

While the financial structure and technique are extremely complex, the fundamental principle of the whole system, its *raison d'être*, is essentially simple. It is this: the financial organs, i.e. the banks, the insurance companies, the stock exchanges, the bill brokers, the issuing houses, etc., are simply links between a special kind of supply and a special kind of demand—the supply of savings and the demand for savings.

Demand and Supply of Savings

First, consider the demand side of the equation. Take the case of a farmer who, let us suppose, specialises in the production of wheat. He has to meet several items of expenditure before he can market his product. The growing of wheat takes time. He sows his seed in the autumn, harvests his crops in August, and sells them probably next autumn. During that year he has had to pay his men, maintain himself, and meet various other outlays. His own savings are not available, for he has sunk them in the farm buildings, machinery, and so on.

To meet this need of the farmer is a function of the bank. By granting the farmer an overdraft, the bank enables him to pay his way until he receives the proceeds of his crop. How is the bank enabled to perform this important service? This question leads to the supply side of the equation, for the bank acts as a middleman between the people who have a surplus stock of money and the producers who require credit to tide them over the period of production.

The people who have a surplus stock which they desire to deposit with the banks may be divided into two classes. In the first are those who desire a safe investment which they can quickly turn into cash if the need arises. A deposit account on which interest is paid offers such people the facility they require. In the second are the people who desire to hold a stock of money in a convenient form on which they can constantly draw. A current account provides just such a facility. The total deposits of a bank are almost equally divided between deposit and current accounts. Then again, the insurance companies, building societies, friendly societies and co-operatives are hardly less important as a means of aggregating the savings of the community and putting them to use. The insurance companies alone have more than £3,000 millions, principally policy-holders' money, invested.

LESSON 6

Short-Term Credit For Traders

ALL production takes time—a circumstance which necessitates the provision of credit by the banks. Even when goods have been produced, there is an interval of time before they can be placed in the hands of consumers. Transport and marketing also take time. This is especially true of international trade. From the time the merchant buys a consignment of cotton piece goods from the Lancashire manufacturer till the time he sells them to his customer in Africa, a period of some months elapses. If the merchant was without the use of his money for so long he would miss many profitable trading opportunities.

Bills of Exchange

To supply this need for credit on the part of merchants engaged in international trade, a special organization has grown up. This organization is the bill market, which is operated by the discount houses and bill brokers. The discount houses and the bill brokers, like the banks, are merely middlemen. On the one hand, they borrow money from banks and other institutions or from private individuals who put money on deposit account with them ; on the other, they advance money to merchants in foreign trade.

The mechanism by which the discount houses advance money to merchants is different from that used by the banks. The banks usually advance money by granting an overdraft, the discount houses by buying a bill of exchange. This is how the mechanism of dealing in bills of exchange works. Suppose merchant X has sold a consignment of piece goods to merchant Y in Africa ; merchant X draws a " bill " on his customer for £1,000, payable in two months' time, and presents it for acceptance to the English agent of merchant Y. When it has been accepted, the bill has become a negotiable instrument in virtue of the fact that anyone who buys the bill can expect to obtain £1,000 from the agent of merchant Y.

The owner of the bill will not be able to obtain its face value, i.e. £1,000, until two months have expired. The interval of two months is, we may assume, the time required for the transportation of the goods from Lancashire to Africa. Hence the bill broker or the discount company, the people who specialise in buying bills of exchange, will not be prepared to offer merchant X £1,000 for the bill. How much will they be prepared to offer ? Clearly, £1,000 less the current rate of interest for two months, the period for which they must be without the use of their money. This transaction of buying a bill of exchange for its face value minus the rate of interest for the period it has to run is called discounting.

Why is a specialised organization necessary for the discounting of bills ? Why could not any firm or individual with the money to spare deal in bills, and thus earn the interest on them ? The answer is that in order to deal in bills successfully a specialised knowledge of the standing and financial circumstances of the merchants who draw the bills and of the merchants on whom the bills are drawn is essential. Otherwise the discounters may find that when their bills mature neither of the parties to the bill is in a position to meet his obligations.

Short-Term Credit Suppliers

The banks and the bill market together form one of the two divisions into which the business of financing industry falls. These two institutions provide industry and trade with the short-term credit which they require. That is to say, they enable producers and merchants to tide over the period that is required for producing a commodity and the period that is required for the transfer of that commodity into the hands of the consumer. But the banks and the bill market do not provide, out of their own capital, the credit thus required : they act as middlemen between the people who have a surplus supply of money and the producers ; in short, their function consists in directing a part of the flow of savings into the channels required to maintain production at a satisfactory level. The other division into which the business of financing industry falls is the provision of long-term credit, i.e. the provision of fixed capital. An outline of the organization required for this purpose follows.

LESSON 7

Joint-Stock Companies

With the development of large-scale enterprise a new problem of organization arose. Before the industrial revolution the characteristic enterprise was a small affair initiated and managed by one man or by a partnership of two or three. The capital was supplied by the business men who conducted the enterprise. Ownership and control were united in the same hands. For large-scale enterprises the aggregation of capital is indispensable ; without this the exploitation of the new industrial, financial, and commercial technique would have been impossible. Hence, with the rise of giant enterprises like the railways, there arose the problem of aggregating capital in large masses.

Growth of Large-Scale Enterprises

Concerns of considerable size existed, it is true, before the industrial revolution. For the most part, however, they were built up from small beginnings by the original owner of the business. The capital necessary for extending such businesses was supplied from the savings of the owners out of past profits. In the case of the railways such methods were obviously inapplicable. The capital required was too vast to be supplied by one individual or by a partnership of individuals. Nor could the railways be started on a small scale and then extended gradually as capital accumulated from profits. A form of organization was necessary which would make possible the aggregation of capital from widespread sources and the concentration of it in the hands of a few men with the capacity to conduct large-scale enterprises. This form of organization is the joint-stock company.

Part Played by Small Investors

The joint-stock company enables the small investor to participate in the ownership of the biggest enterprises without participating in their management. It facilitates, that is to say, the separation of ownership from control, without which the extension of large-scale enterprise would have been impossible. The average investor has neither time nor capacity to conduct the enterprises in the ownership of which he shares. Thus the joint-stock company opens up a great new outlet for savings.

The rapid extension of the joint-stock company, together with the introduction of the railways, gave rise to a further problem in organization. Previous Lessons have pointed out how the banks and the bill brokers act as middlemen between those who have money which they do not wish to lock up for a long period and business men who require credit to tide them over during the period it takes to produce commodities and to place them in the hands of the customers. In other words, the banks and the bill brokers together form the organization which directs the flow of short-term capital.

With the rise of modern industry an analogous form of organization developed to direct the flow of long-term capital. It had become obvious that a link was required between the business men with the capacity and the desire to start new enterprises and the investing public who wished to participate in them. The organization which supplies this link is the long-term capital market. Its most prominent institution is the issuing house. Many issuing houses have a world-wide reputation based on their experience, integrity, and judgement. It is they who do the work involved in the issue of shares to the public. Their importance, however, is far greater than this. The reputation that they have established enables them to act as sponsors to the public for the various issues that are made through their agency. In this way promotion of new enterprises is greatly facilitated, for support of an enterprise by one of the great issuing houses inspires the investing public with confidence in the shares issued under its sponsorship.

Issuing Houses and Underwriters

Thus the main function of the issuing houses and the various kinds of underwriters associated with them is to examine the proposals that are put before them by company-promoters, and, if they have confidence in the concern, to guarantee, for a consideration, the finding of the necessary capital. For this purpose they make use of their name and connexions to raise the necessary capital from the public by inducing it to buy shares in the concern. It is only in the event of their failing in their campaign of persuasion that the shares are left on their hands.

The rise of the joint-stock company was thus an indispensable condition of the exploitation of the new technique. This development of the joint-stock company gave rise in its turn to the company promoter, for the aggregation of capital on a modern scale introduced the need for industrial initiative. It is necessary to distinguish between the initial display of energy and organizing power needed to put a business on its legs and the detailed control of its policy and management once it has been established. The board of directors and the management of a company are responsible for the latter ; the company promoter is concerned with the former.

The function of the promoter, then, is to discern new wants on the part of consumers or to devise efficient methods of satisfying the old ones. He may do this by promoting a company to exploit a new process or machine suggested to him by its inventor.

More frequently, he promotes amalgamations of existing businesses, thereby facilitating the introduction of important economies. Having formulated his scheme, his next step is to obtain the support of an issuing house for the provision of the necessary capital. Thus, the company promoter performs one of the most vital functions in the economic system.

LESSON 8

The National Income

WHAT constitutes the wealth of a country? If one wished to compare the wealth of Britain with that of France, how should one set about it? What should one include in the reckoning and what leave out? Should one merely add up the incomes of the individual members of the two countries, or should one include the material and other forms of equipment for producing wealth?

Capital and Income

In order to answer these questions, an important distinction must be made. The wealth of a community can be regarded from two points of view. It can be thought of either as an existing stock at a particular point of time, or as a flow over a period of time. When wealth is regarded as a stock it is called capital; regarded as a flow over a period of time, it is called income. To ascertain the wealth of a country one must therefore select one or the other of these two points of view.

On the whole, the second point of view, where wealth is regarded in terms of income, is more useful than the conception of wealth as capital. It is more useful to estimate the flow of goods and services during a particular year than to make a list of all the goods in the various stages of manufacture, of the buildings and the machinery, the harbours and docks, the farms and estates, and of all the other wealth existing when the inventory is being taken. The reasons are not far to seek. In the first place, the figure one would obtain by adding together the value of the items of " stock " wealth would be a most inadequate indication of the capital wealth of a country at any particular time. It would, for example, entirely leave out of account the capital invested in education and training. Suppose one were comparing the capital wealth of France and Great Britain. The estimate of the wealth of France would take no account of one of her most important assets, namely, the taste and skill of the French designers and textile and silk workers. The truth of the matter is that it is just as important to invest capital in human beings by educating and training them as it is to invest capital in material equipment.

In the second place, income is a more fundamental concept than capital. For the utility of capital, and therefore the value of capital, are derived from the income it helps to produce. One does not value a machine as one values a glass of milk, for the direct satisfaction it will render; one values it for the contribution that it makes to one's income. In other words, the value of a machine is derived from the value of its contribution to income. The inventory of the capital wealth of a country would consist mainly of factories and machines and docks and other forms of wealth which are only valuable for what they help to produce. In order to find the value of these things, therefore, one would first have to ascertain the value of the income which they help to produce.

What, then, is the income of a country? The obvious answer is that it consists of the sum of the incomes of the individual citizens of that country. One adds Bill Jones's £8 a week to Mr. Brown's £30 a week and Sir Morris Williams' £1,500 a week, and so on until one has exhausted the number of people who possess incomes. This sounds simple enough, but in practice it is difficult to avoid counting some particular item twice over. Thus one must be careful to exclude the allowance a man makes to his wife or children from figuring in the incomes of the latter.

Difficulty of Exact Definition

This example may serve to show how arbitrary it is to restrict reckoning of income to those services which are bought and sold. Most wives, for example, render to their husbands services for which in the aggregate a substantial sum would have to be paid if they were not performed voluntarily. When a man is single, he has to employ a housekeeper, or live in a boarding-house or lodgings where he has to pay for the domestic services that are rendered to him. These payments for domestic services are included in the aggregate income of the community, just as the payments for medical services are included in the incomes of doctors and therefore in the income of the community. But the services voluntarily performed by wives for their husbands are not included. Not less arbitrary is the exclusion from the national income of those services which a man renders to himself. If, for example, a man who has been in the habit of shaving himself decides to go to the barber, he will diminish his real income, for in order to pay the barber he will have to economise in some other direction. The net effect of the change will be threefold : (1) services formerly rendered by the individual to himself will be rendered to him by the barber ; (2) since he has to pay for the latter, the amount available for expenditure on other goods and services will be correspondingly diminished ; (3) the barber's income will be correspondingly increased.

Comparing National Incomes

It is obvious, then, that the figure which is obtained by adding together the money incomes of the inhabitants of a country excludes a not inconsiderable amount of real income. Whether this fact renders such calculations valueless depends on the use made of them. Certainly calculations, however accurate, are quite valueless in themselves. The fact that the national income amounted to about £14,000 millions in 1954 is meaningless unless compared with the national income in other periods in the past or with the incomes of other countries. In making such comparisons, however, it is necessary to allow for differences in the numbers who share the various incomes. This can easily be done by dividing the aggregate income by the total population in each case.

For most purposes one may safely leave out of account those elements of real income which do not enter into the circle of exchange and which therefore do not figure in the money income of the community. If one were comparing the national income of 1955 with the national income of pre-1939 days, it could be safely assumed that services rendered without payment in the two periods were more or less constant. When one is making comparisons between different countries or between two widely separated periods in the history of the same country, it cannot be assumed that this is so.

All services which are bought and sold, then, enter into the reckoning of the national income. Income therefore includes all payments to workers in the form of wages ; all payments to shopkeepers and other middlemen ; all payments to professional men, doctors, lawyers, architects, and so on; all payments to property owners for the use of their property, whether it be land, capital, patent rights, or any other form of property for which payment is made. The total of these payments represents the total money income of the community.

Standards of Living

The comparison of the income of a country over two periods not far removed in time is a fairly simple matter. When comparison is made between the national income of to-day and that of 200 years ago, certain difficulties arise. For example, 18th-century England was predominantly a peasant country, in which the workers derived a substantial part of their income from direct services rendered by the worker himself, or by his wife and children. They produced the greater part of their food, gathered their own fuel, and so on. The money income of such a country is thus not comparable with that of a country like modern Britain, in which direct services are far less important. Even in comparing the income of modern Britain with that of modern France, substantial allowance must be made for direct services which do not figure in the money income of the country ; for France is a country in which the peasant is a predominant feature, and the modern peasant still grows a large part of his food supply, besides rendering other direct services of less importance.

There is a further difficulty, of even greater importance, in making such comparisons. In two countries, or two periods, which are not closely similar, the tastes and needs of the peoples concerned are likely to be different.

Differences in Taste and Need

Take, for example, a comparison between the standard of life in India and that in Britain. One may compare the income per head of India with the income per head of Britain and say that the latter is 15 times that of the former ; that is to say, the average Englishman possesses a money income 15 times as great as that of the average Indian. But this comparison is in terms of money income, not in terms of satisfaction or real income. It is quite possible for country A to have as high a standard of living as another country B, even though its money income per head is much lower. For the inhabitants of country A may satisfy their fundamental needs, such as food, clothing, and shelter, in a much more economical manner than the inhabitants of country B. Thus, country A may have a more congenial climate than country B. The inhabitants of a Mediterranean country, for example, need less expensive clothing and diet, and less provision for artificial heating, in comparison with the inhabitants of a country like Britain.

The comparison of the money incomes of two countries, then, is only a rough indication of the standards of living obtaining in them. Allowances have to be made not only for those elements of income which do not figure in the money income but also for differences of climate and taste. A people with a favourable climate and simple tastes may quite conceivably make a given income go twice as far in real satisfaction as another with a less favourable climate and more expensive tastes.

There is yet a further qualification to be made in such comparisons. When one estimates the money incomes of different countries or of the same country in different periods, it is necessary to make allowances for differences in the value of money. Thus a man with a present income of £1,000 a year, who wishes to ascertain whether he is as well off as he was five years ago with £800 a year, would obviously have to take into account the changes that have taken place in the prices of the various goods and services he consumes. He would find, however, that even if he had all the data he required, the calculation was a difficult one. At first sight it would seem that if he had a list of the prices at both periods of all the commodities he consumes, his task would be quite straightforward. By simple arithmetic he could find the percentage of change in each case, and by striking an average obtain the average change in the level of prices.

Differences in Money Value

A moment's reflection will be enough to show that the figure he obtains in this way would be quite useless. Suppose that our individual spends half his income on food and clothing, and one-twentieth part on beer and tobacco. Suppose, further, that beer and tobacco have risen in price by 100 per cent., while food and clothing have risen by only 25 per cent. If he strikes an average between 100 per cent. and 25 per cent., he will obtain the result that prices have risen by 62½ per cent., which is obviously absurd, seeing that food and clothing, on which he spends half of his income, have risen by only 25 per cent.

In such comparisons there are, broadly, two main difficulties to be overcome. In the first place, the importance of the various commodities is not the same in any two periods. Tastes will have changed. More coffee, for instance, may now be consumed at the expense of alcoholic liquors ; expenditure on cinemas may have assumed a much more important place in the individual's budget. To measure such changes accurately is impossible. In the second place, there is the fact that in the later period new commodities will have become popular items of consumption. Clearly, when one is estimating how far one's income will go to-day as compared with some past year or period, one can make no accurate allowance for this kind of alteration in expenditure.

Nature of Wealth

Before proceeding to consider the factors which determine the size of the national income, it is important to clear up a popular misconception with regard to the nature of wealth. It is often thought that wealth is necessarily concrete. Even Adam Smith, the father of political economy, so regarded it. If, however, one thinks of wealth as something concrete, one falls into the serious error of considering those people who are not engaged in the production of commodities as unproductive. The miner and the cotton operative are thought to be productive ; the doctor, the actor, and the merchant, not. That classification has not the least justification. Anything that is transferable, that can be had in not unlimited quantities, and that satisfies a human want, is wealth. The person who renders services of any kind is productive, just as is the factory worker. The prima donna singing at the opera is productive, just as are the workers employed by the factory which makes gramophone records of her songs. The merchant who makes no tangible alteration to the commodities which pass through his hands may be as productive as the workers who produce them. They are all concerned with satisfying human wants, and therefore they are all productive in the economic sense. Production includes the activity of all those who help to increase the capacity of a thing or a service to satisfy us. They may do this by altering its form or appearance, or by transporting it, or by storing it until we need it.

What are the factors which determine the size of the national income ? Why is it that a country is better off at one period than at another ? Why is it that some countries have a higher standard of living than others ? The income of any country obviously depends on the productiveness, the effectiveness of each unit of effort in that country. Any factor which determines the effectiveness of the work performed by its inhabitants will also influence the size of its income. If, on the average, an hour's work by the average Englishman is twice as effective as an hour's work by the average Italian, then, if they both work the same number of hours, the average Englishman's income will be twice as great as the income of the average Italian.

Factors Influencing Productivity

What are the factors which determine productivity ? They may be classified under the following six headings.

(1) The technical knowledge of a country.
(2) The natural resources that a country possesses, e.g. coal, oil, land, harbours, etc.
(3) The amount of capital, *i.e.* the material equipment.
(4) The industriousness of the people.
(5) The number of the working population.
(6) The efficiency of the economic organization.

To understand the influence of these factors on the effectiveness of effort, and therefore on the size of the national income, it is not necessary to analyse each in turn, since an increase or diminution in any one of them influences the national income in the same way as a similar increase or diminution in any other. Here we concern ourselves with the effects of the introduction of new and more efficient machinery, a typical example of an increase in the first factor mentioned, namely, technical knowledge.

Suppose that a particular firm in the shoe industry introduces a new and more efficient machine. This new machine will enable 500 workers to turn out as many shoes as, say, 1,000 workers could turn out with a machine of the old type. Suppose, further, that the new machine is somewhat more elaborate than the old one, and therefore requires more labour in its production than the old machine. What will be the effects of the introduction of such machines ? The firm introducing them can follow one of two lines of policy. It can retain its 1,000 workers and produce double the quantity of shoes, or it can reduce its staff to 500 and continue to produce the same quantity. The intermediate courses may be ignored, as they would merely modify the results of the two extreme cases.

If the firm decides to double its output, it must lower its price in order to induce the public to buy more shoes. This it will be able to do with the aid of the new machine. In this case the consumers should be better off by virtue of the increased quantity of shoes which are put on the market at a lower price ; and as consumers the workers might be better off too, because they could get their shoes at a lower price and also because there is more employment. For not only is the same number of workers employed as before in the shoe industry, but there is in addition an increased number of workers employed in the machine industry to make the new machines, and in the industries producing raw material for the machines.

But what if the public prefer to buy the same quantity of shoes as before at the lower price and to spend the money which they save in this way on other things ? In this event, when the shoe industry expands its output, the value of the shoes will fall below the cost of production. Losses will result, and the firm will decide to contract its production by throwing a number of its operatives out of employment. At this stage there will be a net decrease of employment, for the expansion of employment in the machine industry, etc., will not be sufficient to counterbalance the unemployment in the shoe industry.

But since the consumers have been able to purchase their shoes at a lower price as a result of the introduction of the more efficient machinery, they will have more money at their disposal to spend on other things. They will probably spend more on luxuries, such as cinemas and chocolates. The luxury industries, finding it profitable to expand production in consequence of the increased demand, may take on more workers. The expansion of employment in the luxury industries, together with that in the machine industry, may more than counterbalance the contraction of employment in the shoe industry. The introduction of labour-saving machinery may therefore result in a net expansion of employment.

But experience leads to emphasis on the *may*. Only in a world in which labour and capital were both entirely mobile could it be said with certainty that the introduction of machinery is to the advantage of everyone concerned.

LESSON 9

National Income and Employment

ANY increase in the productivity of industry, however caused, tends to raise the standard of living and expand the volume of employment. For the same effects as those resulting from the introduction of a new machine are caused by any of the other five factors which influence productivity. The discovery of a new coalfield, an increase in the supply of capital, an increase in the industriousness or the numbers of the working population, an improvement in the industrial organization—any of these factors will tend to raise the standard of living and expand the volume of employment in the same way as an increase in technical knowledge.

It is seen, then, that the national income is not a fixed sum. There is no wages fund which is fixed once for all, and which sets a limit to the volume of employment that is available. Nor is there a definite amount of purchasing power which is fixed once for all, and which sets a limit to the volume of commodities that can be produced and marketed. For every increase in production, whether it be the consequence of a new invention, a discovery of new resources, an increase in the supply of capital, or increased efficiency of the workers, brings with it a corresponding increase in purchasing power.

The industrial machine in Great Britain and other countries was seldom so productive as just before the great slump of 1929 ; masses of goods, manufactured and agricultural, were being poured out in a constant stream. Theoretically, this bumper flow of goods ought to have resulted in a marked rise in consumption. Yet the reverse was the case. So far from being richer, the population of every country, particularly the fabulously wealthy U.S.A., and Great Britain, found its standard of living reduced as a great wave of unemployment spread far and wide. Why was this so ? Because the increase in supply was *not* accompanied by a corresponding increase in demand. The demand was there, it is true ; people were in need, even desperate need, of the foodstuffs, clothing, furniture, and so on, which the factories and fields were turning out in such unprecedentedly large quantities. But the demand was not *effective*. The would-be purchasers had not the wherewithal to purchase : not their desire but their purchasing power was deficient.

Why was their purchasing power insufficient to " buy back " the goods they had produced ? In the process of producing the goods huge sums had been paid out in wages and salaries, in rent to landlords, in interest and dividends to the owners of the " means of production." But of these sums, only a portion—the greater part of the wages and salaries and a very much smaller part of the rent and interest payments—was used by the recipients to purchase the goods that had been produced. The balance, received by the far fewer employers of labour, landlords, property owners, shareholders, and financiers, was not used in anything like its entirety to buy " consumer goods," since their incomes are usually far more than sufficient to maintain their standard of comfort. So far as opportunities for profitable investment presented themselves, it was invested, i.e. devoted to the production of " capital goods," the economist's term for factories, machinery, plant, etc. But what was the use of producing more " means of production " when the product of the capital already employed was not being sold ? So the sums received by the owners of industry were not reinvested : they were left on deposit at the bank, or used to buy shares in already existing companies.

Maldistribution of Income

At bottom, maldistribution of income was primarily responsible for the mass unemployment in the years before the Second World War. In so far as incomes tend to a broad equality, more is spent on consumer goods and less is saved, i.e. is spent on further " means of production." It is true that the addition to society's income enables society to pay the additional workers or machines or organizers. It *enables* society to do so ; but in fact society does *not* always do so, because society is made up of persons with widely differing incomes.

The growth of production must proceed not haphazardly, but in accordance with the needs, or rather the effective demand, of consumers. If, for example, the efficiency of every industry were doubled to-morrow, one would not be justified in assuming that every industry could adapt itself to the new situation by marketing twice the amount of goods produced. Given a doubled efficiency, some industries would find it profitable to increase their output to a moderate extent, others to increase their output by more than the increase in their efficiency, others to maintain the same output as before, while a few industries would find it necessary positively to curtail their output.

One has only to think how one would react to a doubling of one's income to see that this would happen. When a man is poor he is compelled to make bread a substantial part of his diet, to consume but a moderate amount of meat and but a small amount of fresh fruit and vegetables. Suppose his income is doubled. How will he adjust his expenditure on food ? He will spend less on bread than hitherto, perhaps twice as much on meat, probably four or five times as much on fresh fruit and vegetables. Clearly, if the bulk of the community changed their diet in this manner the producers of wheat would be compelled to contract their production in spite of the increased prosperity. But this would not mean that there was not sufficient purchasing power to buy all the wheat that was produced, or that the demand of consumers was fixed. It would mean that the community, being now richer, could afford a more expensive diet.

Effect of Elastic Demand

Whether an increase in productivity will, in the first place, cause dislocation and unemployment depends, therefore, on the kind of industry in which it takes place. If it takes place in an industry for the products of which there is an elastic demand, it may not cause unemployment, even in the initial stages. For the expansion in demand which a fall in price should produce enables the industry to maintain, if not to expand, the employment it provides. An invention in the electronics industry, for example, would be unlikely to cause unemployment ; the demand for television, radio, etc., being highly elastic, the increase in the supply of these things could easily be absorbed at the lower price.

Effect of Inelastic Demand

If, on the other hand, an invention takes place in an industry for the product of which the demand is inelastic it may cause considerable dislocation. This is what happened in the wheat industry in the years before the Second World War. Remarkable discoveries in wheat growing and harvesting led to a great expansion of supply. But the demand for wheat is highly inelastic. Consequently, a considerable fall in the price of wheat did not induce people to increase their consumption of bread. Rather, the contrary was the case. Hence the agricultural sections of Australia, Canada, the U.S.A., and East Anglia were plunged into the direst straits. The distress was intensified by the fact that the process of adjustment to changed conditions is slower in agriculture than in any other industry.

Yet a third industry may be envisaged—one which is altogether or very largely a monopoly. Here the profits derived from increased productivity may be pocketed by the owners. Dislocation is minimised but there is no benefit beyond this for the consumer.

LESSON 10

The Economics of Spending

Economics being the science concerned with the administration of resources, and these being scarce relatively to the multiplicity of human needs, principles for the management of resources are necessary. One aim of economics is, then, to build up a body of laws or principles governing the scientific management of resources. As in other sciences, economic laws (which are really statements of tendencies) vary in the scope of their validity.

Laws of Universal and Partial Validity

The most important laws are of universal validity; others are of only partial validity, depending for their applicability on the existence of certain motives or social institutions. As an example of the first kind of law, take the Law of Diminishing Utility: the more we have of any particular commodity, the less satisfaction we derive from additions to our stock of it. Clearly, this law is as applicable in Soviet Russia as it is in Great Britain. As an example of the second kind of law, take the Law of Supply and Demand, which tells us that the quantity offered and the quantity demanded must tend towards equality. Clearly, this law is not applicable to Soviet Russia, in so far as the government there determines what the supply shall be. Nor did it apply to Great Britain in war-time.

Management of Resources

This and the next Lesson are concerned with the *universal* laws for managing resources. Only one assumption is made, and that is that the individual or the community, as the case may be, is actuated by the desire to maximise the satisfaction to be derived from the means at his disposal. This is the only assumption made in laying down the fundamental principles for the management of resources. In the quest for these fundamental principles the first step is to inquire how an individual spends his income. At first sight the problem seems simple. All he has to do is spend his money on those things which he regards as the most useful to him. A moment's reflection will show that this answer is unsatisfactory. The individual may regard food as the most useful commodity, clothing next, then house room, then books. This classification, however, would not really help him with his problem. He would not spend all his money on food because he thought it the most useful of commodities; nor for that reason alone would he necessarily spend more money on food than on clothes or house room.

The fact is that when an individual is spending his income he never bothers his head about the total utility of a thing to him. When he is buying bread he does not take into consideration the fact that without bread or some adequate substitute he would die. That he does not do so is shown by the fact that the most useful commodities often — nay, usually — are the cheapest. Bread, for instance, is cheap, while pearls are expensive. Nor are these considerations less valid when the matter is considered from this viewpoint.

There are two great principles on which the scientific management of resources is based. The first principle is that of price; the second, that of diminishing utility. These principles are all-pervasive in their application to economic problems. They apply to the management of the resources of a state, of the resources of a great enterprise, of a private firm, and of an individual. The individual who wishes to maximise the satisfaction he derives from the commodities and services his income will purchase must follow these two principles if he is to make the most of its resources.

Importance of Price

When a housewife goes shopping, her first objective is to ascertain the prices of the various commodities she contemplates purchasing. She wishes to know the price of mutton before she decides on beef, the price of cauliflowers before she decides on sprouts. That is to say, before she makes her purchases she wishes to know on what terms she can obtain the various things she wants. She will buy more of a particular commodity if it is cheap than if it is dear; she will not buy any quantity at all of certain other things unless she can obtain them at what she regards as a reasonable price.

Alternative Wants

Thus the way in which income is spent is partly decided by the terms on which the various alternatives are open—that is to say, according to the prices of the various goods and services. For instance, an inhabitant of a besieged town would spend his money differently from the way he would spend it in London under normal conditions. The besieged citizen can be thought of as spending practically the whole of his income on food, whereas the Londoner spends, say, a third; this radical alteration in the management of resources would be due to the difference in the terms on which the various alternatives were open to him.

The price we have to pay for a thing is vital to us because it determines the sacrifice we may have to make in order to get it. The more we have to pay for a particular thing, the greater quantity of other things we shall have to go without. This fact is sometimes obscured by the use of money, especially when "sales" are on. The mere fact that a dress is marked down from 30s. to 19s. 11d. is often an irresistible inducement for a woman to buy it. When she is tempted by this bait she is acting somewhat irrationally. The fact that the dress was once priced 30s. is irrelevant. In deciding whether she shall make the purchase at 19s. 11d. her sole consideration should be whether she could get more satisfaction by spending this sum on the dress than on something else.

LESSON 11

The Meaning of Marginal Utility

As has been explained, the total utility to us of a commodity has no influence on the spending of our incomes; that our total supply of bread is of infinitely great importance to us is simply not relevant to the price we are willing to pay for it. This is due to the fact that the more a person has of anything, the less urgently does he desire additional supplies of it. As Prof. W. S. Jevons, the Victorian economist who first developed the concept of the margin in economic theory, pointed out, we can theoretically divide our supply of any commodity into a number of units. The first unit we should value very highly, if it constituted our total supply. The addition of a second unit to our supply would be of less value to us; and so on until the last unit, which would have the least utility of all. This last additional unit, or increment, to our supply is called the marginal increment, or marginal unit.

Marginal Unit of Supply

As the conception of margins plays a large part in Economics, it is necessary to understand precisely at the outset what it means. The important thing to remember is that the marginal unit of a supply is not a particular unit. *Any* unit may be regarded as the marginal unit. If we lose one unit of a commodity, the extent of our loss of utility is in no way dependent on which particular unit it is. We cannot single out the marginal unit; but we can distinguish between the satisfaction rendered by a number of units of a commodity and the additional satisfaction rendered by an additional unit. The satisfaction rendered by the marginal unit (the unit which we only just decided to add to our supply) we call the marginal utility of a commodity.

The importance of margins in Economics lies in the fact that with regard to any commodity or service which one contemplates purchasing, it is the marginal utility that one takes into consideration. With few exceptions, we concern ourselves only with slight increases or diminutions of the stock of anything. Thus an individual who was reviewing his expenditure with the purpose of laying out his income more economically would consider whether he could dispense with a small portion of his consumption of tobacco or of beer, in order to allow himself a small increase in his supply of books or theatre-tickets.

We can see wherein lies the art of successfully managing our income. It consists in so adjusting our expenditure that the marginal shilling or pound spent on each commodity or service during, say, a year renders us equal satisfaction. For if the satisfaction we derive from the marginal shilling spent on cigarettes is less than the satisfaction derived from the marginal shilling spent on periodicals, then we could increase our satisfaction by diminishing our expenditure on cigarettes and increasing our expenditure on periodicals. While there is no connexion between total utility and price, there is the closest connexion between marginal utility and price. In fact, the connexion is so close that one is entitled to make the following generalisation: A commodity tends to be produced on such a scale and only on such a scale as will enable its marginal utility to remain equal to its price.

If one masters the full meaning of this generalisation, one is equipped to deal with the whole body of economic theory. For the law of marginal utility applies not only to the case of consumable commodities but also to all the factors of production: land, labour, and capital. These tend to be remunerated according to the marginal utility which they possess to the business man who hires them. Thus the same principle determines not only the distribution of our incomes among the various commodities and services, but also the distribution of the total income of the community among the various factors of production.

Marginal Utility and Price

The constant tendency for the marginal utility of a commodity to coincide with its price explains why it is that a change in the price of a commodity brings an immediate change in the amount that will be demanded. If the price of a commodity rises, a smaller quantity will be demanded, and vice versa. For if the price rises, consumers will tend to find that it is in excess of the marginal utility of the commodity to them. They will therefore restrict their purchases and, as a smaller supply implies a greater marginal utility, the marginal utility and the price will again tend to coincide. On the other hand, if the price falls, consumers find that the marginal utility is in excess of the price. They will therefore tend to extend their purchases, thus lowering the marginal utility of the commodity in question.

Housewife and Marginal Utility

To see how this works out in practice, imagine a housewife whose demand for tea is such that if the price is 8s. a lb., she will buy 1 lb. a week ; if 7s. 6d., 2 lb. a week ; and if 6s. a lb., 3 lb. a week. What do these figures, which are called a "demand schedule," reveal ? They reveal that when tea is at 8s. a lb., the housewife does not consider a second lb. worth 8s. ; if she did, she would have purchased it. When tea is at 7s. 6d., she does not consider a third lb. worth 7s. 6d., and so on. One day, we may suppose, she orders 2 lb. of tea at 7s. 6d., whereupon the assistant informs her that the price has fallen to 6s. This being the case, she decides to buy a third lb.

In making this decision she was not considering the utility of the whole 3 lb. in relation to the total price of 18s., for she had already ordered 2 lb. What she was, in fact, considering was whether a third lb. was worth 6s. ; that is to say, whether the addition of 1 lb. to her supply was worth the price. It is equally clear that she will tend to continue her purchases of tea until the value of tea to her at the margin is not less than its price. Thus the price of a commodity measures its marginal utility.

When we say that the price of tea measures the marginal utility of tea to the housewife, the statement means that the utility of the marginal lb. of tea to her is not less than the utility of the commodities she could obtain by spending the money in other ways. This becomes clear if we remind ourselves that we do not desire money for its own sake but for what it will buy. Hence, when we say that a commodity is worth a pound to us, we mean that it is worth the other things which a pound would buy.

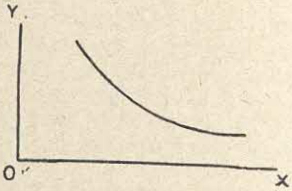
Demand Schedules

In order that a demand schedule may be compiled, it is necessary that all other relevant prices should be known, since an individual can really decide how much he will spend on one commodity only when he knows the prices of the other commodities that he may be inclined to buy. If the housewife did not know the price of coffee, she would consider that she had not sufficient information to decide on how much tea she should buy. Demand schedules, therefore, are compiled on the assumption that all other prices entering into the picture are known.

Demand schedules are conveniently presented by graphs. Thus, in the graph below, distances measured along OX represent quantities of the commodity, and distances along OY represent prices per unit of the commodity.

The curve shown in the graph, which is known as the *curve of demand*, will tend to be directed downwards towards the right, since the lower the price, the more of the commodity will be demanded until no more is required at whatever price.

The rate at which the demand curve slopes to the right varies with different commodities. That is to say, the extent to which a fall in the price of a commodity will stimulate the purchases of it is not the same for bread as it is for cake. The demand is said to be elastic when a slight fall in the price evokes a considerable increase in the quantity demanded, and similarly when a slight rise in the price produces a sharp fall in this quantity.



Demand for Necessities and Luxuries

As a general rule, the demand for necessities is inelastic and the demand for luxuries elastic. Thus a slight fall in the price of bread evokes only a small increase in the amount demanded. On the other hand, bread would have to rise very substantially to curtail demand to any considerable extent. In the case of a luxury commodity like Dundee cake, a slight fall in price generally evokes a considerable increase in demand. The elasticity of demand is said to be equal to unity when the same amount of money is spent on a commodity whatever its price. This, of course, is a purely hypothetical case. If we spend more on a commodity when the price falls, the elasticity is said to be greater than unity, and vice versa.

A confusion sometimes arises over the expression "increase in demand," which may mean one of two things. In the first place, it may mean that, as a result of a fall in price, a larger amount has been demanded—a result which is almost bound to take place. Secondly it may mean that, owing to a change in the taste of consumers or owing to an increase in their incomes, more of a commodity is demanded at the prevailing price. If, for example, a man receives a rise in salary, he may demand more theatre-tickets at the prevailing prices. But equally, if he develops a taste for the drama, he will be willing to curtail his expenditure in other directions in order to spend more on theatre-tickets. In either case, to put the matter technically, his demand curve for theatre-tickets has moved to the right ; that is to say, his demand schedule for that commodity has been changed throughout, since at each price in his schedule he will demand more.

The distinction here made is fundamentally a distinction between changes on the supply side and changes on the demand side. If, for some reason such as the miscalculation of demand or the introduction of a new process, supply increases while the demand schedule remains unaltered, the price must fall ; and this fall in price will induce consumers to demand a greater amount of the commodity in question. If, on the other hand, the demand for a commodity becomes greater, then we become willing to take an increased amount at the price prevailing. There is a change, in fact, throughout the whole range of our demand schedule.

LESSON 12

Methods of Fixing Price

Up to the present we have considered demand in isolation. Taking the prices of the various commodities for granted, we have investigated the principles upon which demand adapts itself to them. We have seen that, from the point of view of the consumer, these prices represent to him the terms on which he can obtain goods ; and that they determine, together with the law of diminishing utility, the way in which he distributes his income among the various alternatives that the market offers. That is, the consumer distributes his income in accordance with the law of price and the law of diminishing utility. But how are the prices of consumers' goods themselves determined ?

The factors which enter into the determination of prices are numerous and complex. It is therefore necessary to carry out our inquiry by stages. In the first stage, take the simplest case—the determination of the price of a particular commodity on a particular day. At this stage the problem is simplified by the fact that the period of time is so short that the supply of the commodity can be taken as given. We can therefore ignore the complex problem of the relation of prices to supply.

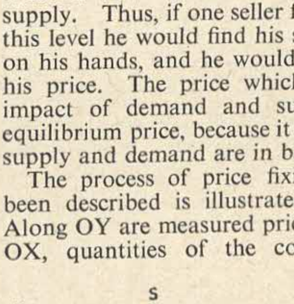
Price in a Particular Market

How, then, is the price of a commodity in a particular market determined ? Take as an example the case of the fish market. We will assume that supplies come in only once a day and that at the end of each day the whole supply must be sold, otherwise it will go bad. The supply of fish, then, is fixed and the demand of the purchasers is also fixed. In this simple case how is the distribution of fish among consumers determined, and what generalisations are we entitled to make about the resultant price at which it will be distributed ?

We have assumed that the rate of consumption, i.e. the amount taken off the market on any particular day, must be made to equal the supply. This implies that the price must be high enough to cut off all demand in excess of that amount. On the other hand, the sellers must dispose of all their fish, which implies that the price must be low enough to allow all the fish to be sold. We also know that each consumer will desire to get his supply as cheaply as possible, and that each seller will desire to obtain the highest possible price.

These data enable us to make the following generalisation as to the price that will be fixed. In a market such as we are considering the price tends to be the highest at which the entire stock can be disposed of. The price cannot be lower than this, otherwise the demand will be in excess of supply. Purchasers will be clamouring for more fish than can be supplied to them. On the other hand, prices cannot be higher than that price which, once established, will just clear the market. If they were, the demand which this price cuts off would be so great that an insufficient demand would be left to take over the whole supply. Thus, if one seller fixed his price above this level he would find his stock was being left on his hands, and he would be forced to lower his price. The price which results from this impact of demand and supply is called the equilibrium price, because it is the price at which supply and demand are in balance.

The process of price fixing which has just been described is illustrated by the diagram. Along OY are measured prices per unit ; along OX, quantities of the commodity. As the amount brought in for sale is independent of price, the line SS, representing the conditions of supply, will be parallel with OY.



The line DD, illustrating the conditions of demand, will slope away to the right in accordance with the law of diminishing utility. The point P, where the two lines SS and DD intersect, indicates the equilibrium price. The diagram shows incidentally that all demand which is not prepared to make the sacrifice involved in paying the market price is cut off.

As a simple example to illustrate the workings of a market, suppose there are five bicycles offered for sale and there are six prospective purchasers. Suppose further that one man is willing to give £15 rather than go without a bicycle, a second will give £12, a third £10, a fourth £9, a fifth £8, the sixth man only £7 10s. Assuming, as in the case of the fish market, that all the bicycles have to be sold, what price will ultimately be fixed ?

The price of the cycles must satisfy two conditions. First, it must be high enough to exclude one purchaser ; for there are six purchasers and only five cycles. Second, the price must be low enough to secure five purchasers, otherwise the whole supply would not be sold. To satisfy the first condition, the price must be higher than £7 10s., otherwise the sixth prospective buyer would not be excluded. To satisfy the second condition, the price must not be higher than £8. For, if it were higher than £8—say, £8 10s.—there would be only four purchasers, and one cycle would remain unsold. Thus the price per bicycle must be fixed somewhere between £7 10s. and £8.

We see, then, that if we know the demand schedules of consumers on the one hand, and the amount of a commodity that is in the market on the other, we are in a position to ascertain the price that will ultimately obtain. This price is called the equilibrium price, because once it has become established in the market there is no tendency for it to rise or fall.

In the example of the five bicycles, suppose the actual price of the bicycles was fixed at £7 15s. Then all the buyers thought they gained by the transaction, respectively £7 5s., £4 5s., £2 5s., £1 5s., and 5s., their estimates of the value of the bicycle being £15, £10, £9, and £8. This gain—the difference between what an individual has to pay and what he would be prepared to pay—is often referred to as consumer's surplus. The marginal purchaser is the one who has practically no consumer's surplus. Similarly, we speak of the producer's surplus or the seller's surplus, the difference between the lowest price the seller would accept and that which he really gets.

It is helpful to distinguish (a) subjective value, the importance that an individual attaches to possessing an additional unit of a commodity, i.e. its marginal utility to him ; (b) subjective exchange value, the rate at which an individual would be willing to exchange one commodity for another ; when one of the commodities is money, the subjective exchange value is the price the individual is willing to pay ; (c) objective exchange value, the rate at which an exchange takes place. The consumer's surplus is the difference between (b) and (c). In the case of the prime necessaries of life and conventional necessaries, the difference tends to be very large.

LESSON 13

Rationing and the Price Mechanism

THE equilibrium market price of a commodity is, as previously explained, the price which, once established, has no tendency either to rise or fall so long as the conditions of demand remain unchanged. If the price should happen to be above this level, the whole stock of the commodity cannot be disposed of. If it is below this level, consumers will demand more than the supply can satisfy. In either case competition will cause the price to move towards the equilibrium price, which is the highest price at which the market can be cleared.

The equilibrium market price of any commodity has a double significance : on the one hand, as regards the distribution of the commodity among consumers ; on the other hand, as regards the future supply of the commodity.

Importance of Distribution

The problem of distributing a commodity among consumers is obviously of the first importance. It is, in fact, as important as production itself. For a commodity virtually becomes wealth only when it comes into the possession of a person capable of deriving satisfaction from it. A set of golf clubs would not be regarded as wealth by a South Sea Islander, nor a bottle of whisky by a rigid teetotaller. Moreover, the problem of distribution is further complicated by the law of diminishing utility. It is not merely a question of getting the right commodity into the right hands ; there is also the question of the very best quantitative distribution.

Principles of Rationing

Goods are scarce in relation to the demand for them. Hence it is necessary that some mechanism should exist by which demand is restricted to the supply available. There is the mechanism of rationing, and the mechanism of prices in a free market. Under the rationing system the individual is not allowed to buy as much of a commodity as he is prepared to pay for ; he is restricted to the amount laid down by the authority which controls the rationing system. This authority has also to determine the prices which the shopkeepers shall be allowed to charge, since prices can no longer be determined by the free competition of buyers and sellers.

In the first place, rationing enables numerous economies to be achieved in the marketing of commodities, thereby liberating energy and power, which can be devoted to other purposes. In the second place, it greatly facilitates the problem of production by substituting stabilised production for the unequal production governed by a highly fluctuating market, since the consumers have to take what is produced. In time of war, or in periods when the supply of vitally necessary goods is severely limited, the need for rationing may be imperative.

The advantages of the system of rationing can be obtained only at the sacrifice of the freedom of consumers to spend their incomes in whichever way they please.

Sacrifice of Consumers' Freedom

And this sacrifice of the freedom of consumers involves considerable loss in the satisfaction derived from the consumption of the goods produced. For, in the first place, the system of rationing requires that the public authority which controls the system shall determine the kind of commodities the public shall consume, as well as the amount of each commodity that each member of the public shall consume. The success of the system would therefore depend in part on the capacity of the authority to ascertain the needs of the consuming public ; and the nature of such a task might be expected to tax the capacity of any public authority, however diligent and able it might otherwise be.

The limitations of the rationing system are not confined to the difficulties involved in its administration. For the rationing system can take no account of individual differences. It compels each individual to take the same kind of commodities in the same quantities as the other individuals with whom he is classified.

No Free Choice

He is thus deprived of the freedom of distributing his income among the various articles of consumption according to the terms on which they are available. Nor is he free to substitute at the margin a quantity of one commodity for a quantity of another which he values more highly. In other words, he is prevented from maximising the satisfaction he could obtain from his income

Thus the substitution of a system of rationing for the price mechanism and the freedom of consumers to buy what they please involves a sacrifice in human satisfaction; and the extent of this sacrifice is not inconsiderable, even though it tends to be counterbalanced by the securing to those in the lower income groups of the basic necessities of a civilized existence.

By allowing freedom of choice to consumers in the expenditure of their incomes, distribution of the available commodities in such a way as to promote the greatest possible satisfaction of the individual consumer is achieved. For each individual will distribute his income, in so far as he acts reasonably, according to the law of price and the law of marginal utility, thereby obtaining the maximum satisfaction from his available resources.

The Price Mechanism

The freedom of consumers' choice, however, involves the mechanism of prices, since some means must exist to equate demand with supply. This function is performed by prices, price being thus an essential piece of mechanism by which demand in excess of available supply is cut off.

LESSON 14

How Prices Affect Economic Activity

So far we have taken the supply for granted. That is, in our analysis of the process by which the equilibrium price is determined we took the amount of fish supplied to the market as given ; we did not inquire what factors had determined the amount of fish supplied to the market on that particular day. A storm may prevent many fishing vessels from leaving port, or the fish may be particularly scarce in the regions which are being trawled. On some days, therefore, the supply is considerably below normal, on others it is particularly abundant. Such fluctuations tend to even out over the course of the year, and have no influence on the average supply. Similarly with agricultural produce, alternations of abundant harvests and scanty harvests are experienced, but these fluctuations do not influence the average supply of agricultural products. The average supply is determined by factors other than these accidental circumstances.

The average supply of a commodity is determined by the amount of capital, labour, and natural resources devoted to the production of it. The supply of fish, for example, over the course of the year is determined by the number of ships and the extent to which they are adequately equipped, together with the numbers and skill of the crews. This explanation, however, does not take us very far. It does not explain why there is just the amount of capital and labour in the fishing industry which is invested in it. It is necessary to know the factors which determine the flow of the available resources into the various industries. One of the most important determining factors is Price.

Clearly, the price which is established in the fish market will react on the future supply. If the price is such as to yield exceptionally high profits to the producers, and if this price is not due to an exceptionally small supply (as a result of a storm at sea or some other incident which has reduced the supply below normal), then new capital and labour will be attracted into the industry. The high rate of profit will attract the new capital which is seeking investment. New undertakings will therefore be set up in the fishing industry, and, in order to attract the necessary capital and labour, high rates of wages will be offered. When these new undertakings have got going, however, the supply of the commodity will begin to increase. This increase in supply will cause the price to fall, a fact which in its turn will reduce profits. Hence, the inducement for new capital and labour to enter the industry which the exceptionally high profits offered will cease as soon as the supply has been increased to the required extent.

On the other hand, if the price established in the market is below normal, capital and labour will tend to go elsewhere, thereby reducing the supply and so raising the price. This process will go on until the price is raised to a normal remuneration to the capital and labour employed. Thus there is always a tendency—it is no more than a tendency, since capital and still less labour are not completely *mobile*—for the net rate of profit and the rate of wages for labour of the same grade to be equal in all industries. If they are not equal, there is always a greater or lesser inducement for labour and capital to move from the less profitable to the more profitable industries.

Mobility of Capital and Labour

But, it may be argued, this may be all very well in theory ; how can the process operate in practice ? How can capital which has become embodied in ships and tackle and other forms of equipment be transferred to other industries ? It is, of course, true that capital which has become embodied in material equipment cannot be transferred from one industry to another. This fact in no way invalidates the argument that if the profits of an industry are below normal, the amount of capital employed in that industry will diminish. For if capital cannot be employed at a profit in the industry, it will no longer pay to replace the equipment as it wears out.

Thus the profits earned in any industry, after allowing for risk and similar factors, cannot diverge for long from the profits earned in other industries. There is a constant tendency, that is to say, for profits to seek a common level throughout the field of investment. What is true as regards the remuneration of capital is also true as regards the remuneration of the other factors of production. If the wages of any particular grade of labour are higher in one industry than in another, then (after allowance has been made for such factors as the relative agreeableness of the work or the regularity of employment) labour will be attracted to the industry which offers the higher wage. Nor is it necessary, in order that the labour supply should adjust itself in this way, that any of the workers in the low-wage industry should transfer themselves to the high-wage industry. For every year a great army of new recruits to industry is absorbed in employment. It is therefore possible for the transfer to take place by the diversion of the new workers from the one industry to the other. If the contraction of an industry is rapid the diversion of recruits may have to be supplemented by the transfer of a proportion of the workers in the contracting industry. The transfer of men who have been long engaged in an industry presents far greater difficulties than the diversion of new recruits.

Rent—the Landowner's Remuneration

The remuneration of landowners for the use of their land, which is termed rent, is subject to the same tendency as the remuneration of capital and of labour. If in a particular district —say, on the fringe of a large town—a higher rent is offered for land as building sites than is offered for land used purely for agriculture, then a transfer of land from the latter use to the former will take place. This process will continue until the transfer is no longer profitable ; that is to say, until the rent of land of like quality and of like advantages of situation is equal.

The significance of prices in relation to supply has now been traced. It has been seen that if the price of a commodity rises, and if the rise in price is not due to changes in the condition of supply, then the quantity offered will increase. But, it may be asked, what justification is there, from the point of view of the consumers, for this increase in quantity? The answer is that the rise in price is an indication of an increase in demand. For if the price of a commodity rises while the conditions of supply remain unchanged, then the rise in price must necessarily be due to an increase of demand.

Fundamental Role of Prices

Thus the mechanism of prices plays a fundamental role in the economic system. Prices, in fact, are the regulators of economic activity ; they regulate production in accordance with the demand of consumers. If consumers demand more of a commodity than is being produced, the increased competition among them to secure the available supply will tend to raise the price of that commodity, thereby indicating to producers that an increased supply is called for. The necessary increase in supply will tend to be forthcoming, because the rise in price will make it profitable to expand the production of the commodity in question. This expansion will tend to continue until the price falls to a level at which any further expansion is unprofitable. Here it may be emphasised once again that the demand we have been referring to is *effective* demand. A man may " demand " a great quantity of good things—food, clothes, house-room, amusements, etc.—but if he has no money in his pocket, his " demand " is as good as non-existent.

LESSON 15

Demand and Unequal Incomes

As each consumer, in so far as he is rational, spends his income on the various commodities in accordance with the principles of economic management (the principle of price and the principle of diminishing utility), the distribution of commodities which results from the freedom of consumers' choice is the very best distribution obtainable in the given circumstances. That is to say, the maximum of satisfaction will be obtained from the available supply of commodities when, on the one hand, consumers are free to spend their incomes as they please, and when, on the other, sellers are free to charge what they can. Conversely, interference by some public authority with the freedom of buyers by a system of rationing or by the control of prices should, if that assumption is correct, result in a loss of human satisfaction.

Distribution of Incomes

This analysis, however, does not justify one in concluding that what is known as laissez-faire—the principle of non-interference—as regards the spending of incomes will result in the greatest aggregate satisfaction from the consumption of the available goods and services. For we have made two highly important assumptions. In the first place, we have not up to the present taken account of the circumstances in which the incomes of consumers are spent, and, in particular, we have paid no regard to the most important of these circumstances—the way in which incomes are distributed ; and it is a fact that our conclusion holds good only if incomes are distributed according to need, that is to say, according to the capacity of individuals to derive satisfaction from the expenditure of income. If distribution is not in accordance with need, then to that extent our conclusion is invalidated.

To what extent does the distribution of income in Great Britain fall short of this standard? The obvious answer is that it falls short of our standard to the extent to which distribution is unequal. But this is to assume that the needs of individuals are equal, which they certainly are not. For not only do the needs of an individual vary with his occupation, they vary also with his culture.

While, therefore, we are not entitled to assume that unequal distribution is necessarily incompatible with our optimum standard, there is nevertheless a strong presumption in favour of the view that extreme inequality of distribution is so. It is very unlikely that a man with £10,000 a year obtains as much satisfaction from the marginal £100 of his income as a man with £500 a year obtains from the marginal £100 of *his* income. If he does not, then aggregate satisfaction could be increased by a transference of income from the richer man to the poorer.

Inequality of incomes offers considerable scope for increasing the aggregate satisfaction derived from the total expenditure of income by state intervention, for the state can increase satisfaction by transferring a part of the income of the rich to the poorer classes.

There are two principal methods by which the state can effect this transference. The money which it raises from the rich by taxation can be transferred to the poor directly, in the form of pensions, children's allowances, etc., or indirectly by subsidising the supply of commodities or services consumed by the poorer classes of the community. The state can, for example, subsidise housing, health services, education, and so on.

State Subsidies

The preference of the state for the indirect method is chiefly due to the irrationality of consumers. The state considers that there are certain needs, such as education, health, and housing, which are of fundamental importance, and that it had better expend the money on these things rather than trust the consumer to do so himself.

For there is always the possibility, if redistribution of income were to take place in money instead of in kind, that the recipient would spend it on beer or dog-racing or suchlike instead of on house-room and education.

We are thus brought to the second of the assumptions on which our conclusion as to the expenditure of incomes was based, namely the rationality of consumers. Clearly, if this assumption is not valid, then there is no justification for the belief that incomes are expended to the best advantage. In so far as consumers are not rational, there is scope for authoritarian interference with consumption.

No one would deny that there are certain goods and services the consumption of which by a considerable section of the public is irrational. To allow the public freely to consume such drugs as cocaine and heroin would be highly dangerous. In Great Britain there is a belief that the public is not sufficiently rational in the consumption of alcoholic liquors and tobacco. The state therefore pursues the policy of restricting consumption by heavy taxation and the compulsory closing of public houses at certain hours.

LESSON 16

Mercantilism and Laissez-Faire

PRIOR to the middle of the 18th century it was found necessary in Britain to regulate in the public interest the enterprise of the individual in almost every sphere of economic activity. In the Middle Ages the employment of labour, the management of business, the buying and selling of commodities, and the prices at which commodities were sold, were all subject to elaborate regulation by the authorities, while speculation and the lending of money at interest were strictly prohibited. Nor were these regulations abandoned in the subsequent period between the end of the Middle Ages and the beginning of the industrial revolution — the Mercantilist Period as it is sometimes called. In some directions they were relaxed; in others they were extended.

Mercantilist Regulations

A brief consideration of the principal regulations of the Mercantilist Period will help to give a clearer understanding of the function of the price mechanism. The most instructive example, perhaps, is the control to which the production of corn was subjected until the beginning of the 19th century. As during the period in question bread was the main constituent of the people's diet, it was thought that the state should ensure an adequate supply. Accordingly, numerous Corn Laws were passed, presenting an elaborate system of bounties to be paid when prices were low, prohibitions of export to be enforced when prices were high, and a complex tariff on imports.

Numerous measures also were adopted to foster the production of woollen cloth, which was the principal manufacture of that time. Regulations governing the manufacture and the quality of cloth were laid down, and staffs of officials were appointed to enforce them. Moreover, to stimulate the production of woollen cloth and thereby increase the volume of Britain's foreign trade, the export of raw wool was prohibited. This measure, it was believed, would result in a more abundant and cheaper supply of wool for the home woollen industry. In addition to the code regulating the production and sale of commodities there were stringent provisions with regard to the supply and wages of labour. Every worker in industry, for example, was compelled to serve several years' apprenticeship before he could practise a trade. Nor were the wages of labour permitted to be determined by the free play of supply and demand. The magistrates were empowered to fix wages annually in the various occupations, and any worker who demanded a wage higher than the regulation wage was liable to be punished. Capital was also subject to control. The Law of Usury, passed in the reign of Queen Elizabeth I and not abolished until 1854, prohibited a rate of interest above 5 per cent.

Foreign trade, however, was regarded as the most appropriate sphere for government intervention. The laws regulating foreign trade resulted from the view that international trade was an economic war, in which the victor was the country which contrived to transport the larger quantity of its commodities across the frontier of its rival, for the loser would thereby be compelled to settle the balance of its indebtedness in gold and silver, which were regarded by statesmen as the only true form of wealth. In pursuit of this objective, imports were controlled by complex duties, while exports were stimulated by bounties, etc.

Arguments of Adam Smith

To discredit this code of regulations was the main purpose of Adam Smith's *An Enquiry into the Nature and Causes of the Wealth of Nations*, the first comprehensive treatise on Political Economy or Economics, published in 1776. His argument was in two stages. The first was concerned to show that there were forces at work in the economic life of the nation which would of themselves, without any aid from the state, direct industry and trade into the channels required by the public good. The second stage was concerned to show that state interference of the kind that was practised was not only unnecessary but was positively injurious.

The first stage in Smith's argument forms the core of his theory of Economics. Here for the first time was given an analysis of the price mechanism—an analysis upon the basis of which economists from that day to this have been steadily building up a structure of theoretical economics. The main conclusion which results from this analysis is that over the greater part of industry and commerce self-interest may be identified with the public good. This identity of the individual and public interest, argued Smith, was brought about by the mechanism of prices. For as a consequence of the free play of supply and demand, the more efficient an individual is in contributing towards the satisfaction of the wants of the public, the higher will be the price he is able to demand for his services.

> By directing that industry in such a manner (said Smith) as its produce may be of the greater value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention.

It is quite a mistake to suppose that Adam Smith and his followers advocated complete laissez-faire. For example, they were all in favour of high wages, and they advocated various measures which would, in their view, raise wages above the prevailing level. Their less-informed converts, however, carried the doctrine further. Bastiat, a prominent French economist of the mid-19th century, wrote :

> He who has arranged the material universe has not withheld His regard from the arrangement of the social world . . . I believe that all that is necessary to the gradual and peaceful development of humanity is that its tendencies should not be disturbed, nor have the liberty of their movements [of individuals] destroyed.

Through the greater part of the 19th century the most prominent developments seemed to confirm the laissez-faire doctrine. The growing power of man over his environment, as manifested in the railway and the steamship, the extraordinary progress of industry, the rapid rise in the standard of living of all classes—especially after 1850—all seemed to add practical proof to the views held by the most optimistic advocates of laissez-faire.

Moreover, striking confirmation seemed to come from outside the economic sphere. Darwin's doctrine of Evolution provided an analogy between the beneficence of free competition, the struggle for existence in nature and that of free competition in industry.

> The economists were teaching [wrote Lord Keynes (1883–1946)] in 1936] that wealth and machinery were the children of free competition—that free competition built London. But the Darwinists could go one better than that—free competition had built man. The human eye was no longer the demonstration of design, miraculously contriving all things for the best ; it was the supreme achievement of chance, operating under conditions of free competition and laissez-faire.

If one allows for the circumstances of Adam Smith's day, it is hard to believe that the case for laissez-faire in his book *Wealth of Nations* is overstated. For not only was the business enterprise of that day hampered in numerous directions by regulations which had long outlived their utility, but the institutions through which the state exercised its control were quite ineffective for the purpose. Effective institutions for government control did not, in fact, exist. The Civil Service, the creation of which was one of the great achievements of the 19th century, had yet to be built up ; trade unions and organizations of employers did not emerge in their modern forms until well on in the 19th century. Moreover, the business unit was as yet too small to be effectively controlled. Thus the state had to feel its way before it could become an effective instrument of control.

Economic theory tends to reflect the prevailing economic practice. In the generations following Adam Smith laissez-faire seemed to be the policy that best furthered the extension of British commerce and industry. Not until the 19th century was more than half over did a small but constantly increasing body of economic thinkers come to see in the action of the state a possible alternative to " cut-throat competition," with its accompaniment of periodical crises, slumps, international rivalry, and—though this was later—wars on a world-wide scale. Before the state could control, still more before it could actually enter the field of industry itself, it had to be modernised.

LESSON 17

State Interference in Industry

This Lesson is concerned with the deficiencies of the price mechanism which create the need for state interference (the word is used here not in any critical sense). It is, of course, possible to hold the view that the mechanism of prices is so defective in its function of regulating production and distribution that to attain a tolerable economic system it is necessary to supersede the whole structure of capitalism. This view is held, in fact, by the communists, and by many socialists. It can hardly be discussed in this Course, since it is based on certain tenets, such as the Marxian dogma of the inevitability of the class struggle and the competence of public enterprise, which are outside the scope of Economics.

These tenets are, in fact, derived not from a criticism of the mechanism of prices but from a denial of certain assumptions, such as that private enterprise can be made reasonably effective, that the competition among capitalists is on the whole beneficial to the community, and so on. These assumptions may or may not be valid. It is, however, convenient to assume their validity for this present inquiry, for we are thus enabled to analyse the mechanism of prices under the best possible or ideal conditions, thereby following the scientific method of isolating, as far as possible, the question under consideration.

We shall not, therefore, be here concerned with the problem of monopoly, or that of the mobility of the factors of production. We shall, that is to say, continue to assume that competition is sufficiently free for prices to correspond to the cost of production, and that capital and labour are sufficiently mobile to transfer themselves to the parts of the economic system where they can be most profitably employed. Nor shall we question the adequacy of the profit motive in stimulating efficient management.

The defects of the mechanism of prices may be divided into two categories : (1) those cases in which the individual and public interest do not coincide ; (2) those cases in which, though there is a coincidence of interest, the individual, through lack of knowledge, enterprise, intelligence, or money, cannot pursue his best interest.

Defects of Price Mechanism

In the first place, the production of a commodity may incidentally inflict a loss on the community which is not borne by its producer. The development of a particular industry, for example, may involve a wholesale destruction of the amenities of the locality. The development of the coalfields and the Black Country testify to this danger. Besides the destruction of amenities, the production of a commodity may be detrimental to public health owing to the pollution of the atmosphere which it entails. Moreover, the pollution of the atmosphere involves damage to buildings and involves increased washing bills. Thus the community has realized, as a result of experience, the necessity for laying down regulations governing the setting up and the running of industrial establishments.

While the amenities of the towns are to a large extent protected from industrial development, the amenities of the countryside are still exposed to this danger. As the trend of industrial development is taking the factory into the country, the danger is a real one. A clear example of a present-day clash of interest between the individual and the community is to be seen in "ribbon development." To the builder, sites along the new main roads are eminently suitable, as they save him the expense of laying down roads, and he is thus enabled to build houses at a lower price. From the point of view of the community, however, this ribbon development has resulted not only in a loss of amenity but also in a loss of public money. For it is more expensive to provide such services as gas, electricity, water, drains, and so on, to a locality in which the houses are spread over a large area ; and this burden is largely thrown on the local rates.

Thus the rise of new industries in hitherto unindustrialised districts, the enormous extension of housing to relieve the congestion of the towns, the great expansion in road construction to meet the requirements of modern road transport —all this new development which proceeded at a great rate between the two world wars must be subjected to social control if the public interest is to be protected.

Protecting the Workers

A most important divergence of interest arises out of the use of processes which are liable to injure the workers who participate in them. In this connexion a series of statutes were laid down, with regulations including the compulsory fencing of machinery, safety measures to be taken in mines, and the payment of workmen's compensation.

There are certain enterprises which, while they are unprofitable to private enterprise, are highly profitable to the community. Lighthouses perform a function of incalculable value. Why, then, are they not a profitable business proposition ? The answer is that a private company could not collect payment from the ships that make use of them.

Another example of this kind of need is the supply of information in regard to the activity of trades. To provide this is the purpose of the Census of Production and the Census of Distribution, conducted periodically ; the Trade and Navigation Accounts—the so-called "Board of Trade Returns"—issued monthly ; and the great quantity of other statistics published in the Board of Trade Journal, the Ministry of Labour Gazette, etc.

Government Research

Much of the research undertaken by the Department of Scientific and Industrial Research, the Medical Research Council, the Ministry of Agriculture, the Atomic Energy Authority, and other government bodies is beyond the resources or the legal powers of private undertakings, though of extreme importance for the welfare of the community. Some of the nationalised bodies, such as the National Coal Board and British Railways, were established because it was thought that the existing privately owned undertakings could not function efficiently. The Export Credits Guarantee Department of the Board of Trade undertakes a form of insurance that the commercial world had needed but had been unable to contrive with its own resources.

LESSON 18

Value and Price and "Real Costs"

The greater part of any text-book on economics is taken up with the question of *value*. The principles which determine the value of commodities and of the various factors of production comprise the bulk of the theoretical parts of the book.

As previously explained, the fundamental principle of the economic organization is specialisation. The latter implies that production takes place not for direct consumption, but for exchange. The goods and services which we supply directly to ourselves are very unimportant in comparison with those which we obtain by exchange. Hence, then, the importance of value, for production for exchange instead of for direct use gives rise to two problems.

Rates of Exchange between Goods

First, determination of the rates at which the various commodities exchange for one another; why, for example, does an ounce of gold exchange for a greater number of tons of iron, or a bushel of wheat exchange for a greater amount of money than a bushel of oats? Second, the problem of distribution. For specialisation implies co-operation; the production of a motor car, for example, requires the co-operation of many kinds of labour, as well as of capital and land. But on what principles shall the value of the motor car be divided amongst the various factors of production which have co-operated in producing it? What proportion of the total value shall be reckoned as interest on the capital, how much shall be set aside for rent for the land, how much as wages for skilled labour, how much for unskilled?

Problem of Distribution

The problem of distribution consists in ascertaining the principles on which the product of industry is to be divided among the co-operating factors of production. The share which a factor receives is, from another point of view, the value of that factor. Thus the wage which a worker receives is from his point of view his share of the value of the products he has helped to produce, but from the employers' point of view the wage which he pays is the price or value in terms of money of the services which he obtains from the worker. The same considerations apply to interest, which is the distributive share of capital, and to rent, which is the distributive share of land. Thus the problem of distribution is one aspect of the problem of value.

The term value as it is used in Economics generally means *value in exchange*. Thus the value of a commodity is the power which it possesses when it is exchanged for other commodities. The value of wheat, for example, is the power which it possesses to obtain other commodities. Wheat rises in value when the amounts of other commodities which can be obtained for a given amount of it increase, and vice versa. Thus values express ratios: the ratios in which things exchange for one another. If a loaf of bread costs 8d., and a lb. of tea costs 6s., then a loaf of bread exchanges for a lb. of tea at the ratio of 8d. to 6s., i.e. 1 : 9.

Values Expressed in Prices

As commodities are not exchanged directly against one another, but through the medium of money, all values are expressed in prices. The expression of values in prices enormously facilitates the comparison of the values of commodities, since we are thereby saved the trouble of comparing the ratio in which each commodity exchanges for every other commodity. Prices represent generalised purchasing power, so that when we know the price of, say, a bicycle, we not only know the ratio in which it will exchange for any particular commodity of which the price is known, but also the ratio in which it will exchange for things in general. Instead of values, then, we may speak of prices.

Consumers' Goods and Capital Goods

The kinds of things that are priced may be divided into two categories: the goods and services which directly satisfy our wants, and the things with which these goods and services are produced. The former are the commodities, goods and services, which are available for consumption, i.e. consumers' goods. The latter are the land, labour, and capital which are available for production, i.e. producers' (or capital) goods. The prices of these two categories of things are determined in very much the same way.

The influences which determine the price of a commodity are of two kinds—the influences which lie behind demand and those which lie behind supply. The interplay of the influences behind demand and supply determines prices. The problem of the determination of prices resolves itself, therefore, into an analysis of the influences which underlie supply and demand.

In our analysis of demand it was seen that the price of a commodity must not exceed its marginal utility to the purchaser; in our analysis of the price mechanism we also saw that the price of a commodity must not exceed in the long run its cost of production. These two characteristics of prices indicate the direction of our inquiry; we must, that is to say, investigate respectively the influence of cost of production and utility on the prices of commodities.

In order that a supply of a particular commodity may be forthcoming certain costs have to be incurred. What are costs ? The answer depends on which of the three possible points of view it is decided to take. There is the point of view of the organizer who is running a business ; that of the individual who co-operates in production ; and that of the community as a whole.

Costs of Production

From the point of view of the organizer costs consist of the money outlays that he has to make in order to place a supply of goods on the market. He has to hire various kinds of labour, to secure capital from the banks or from the public, and to rent land. These outlays, together with his own remuneration, make up his cost of production. In the long run these costs must equal the price he obtains for his product, otherwise he would have no incentive to carry on his business.

His own remuneration is what is left after he has paid wages, interest, and rent. It includes his own wages and a residue, or profit.

To say, however, that the price of a commodity in the long run must equal the sum of the money outlays involved in its production does not tell us very much. It merely pushes our analysis one step forward. What determines the amount of these money outlays ? As all money costs of production resolve themselves into wages, interest, rent, and profit, we have next to inquire what determines the rate of wages, the rate of interest, the rent of land, and the profit of the entrepreneur.

Meaning of " Real Costs "

The analysis of costs from the point of view of the organizer (or entrepreneur, as he is usually called in Economics), in the previous paragraphs, does not take us very far. We want to get behind the money costs to the underlying " real costs " of production. Now, the term costs suggests sacrifice. We speak of a thing as costing us so much trouble or effort or time, and in doing so we imply that the getting or doing of a thing involves a sacrifice. This manner of speaking is especially appropriate to getting one's living, which involves the sacrifice of trouble, effort, and time. Here, then, is one of the elements in the " real costs " which underlie the money costs, namely, the " real costs " involved in any kind of work.

In addition to the expenditure of effort, production also involves the use of capital. Are there also " real costs " underlying the supply of capital ? Capital is, of course, the outcome of saving, and saving involves sacrifice. It involves sacrificing the present to the future. The older economists used to talk of " the sacrifice of abstinence " involved in the supply of capital. Although this phrase is strictly correct, for saving obviously involves abstaining from spending, nevertheless it is too provocative of mirth to be satisfactory. The idea that the rich, who up to now have supplied the bulk of the savings of the community, are undergoing abstinence in order to make available their contribution to the supply of capital is, in its obvious sense, more than a little ridiculous. Much capital for industry is now provided by insurance companies from the sums paid by policy-holders, and by companies from profits " ploughed back" into the business.

The fact that a good deal of saving takes place without any sacrifice does not invalidate the view that there are real costs underlying interest, which is the money cost of capital. It is equally true that much work is done without any sacrifice, but this does not invalidate the view that real costs underlie the wages of labour.

Labour and Sacrifice

A good deal of the work of artists, craftsmen, and professional men, far from exacting any sacrifice from those who perform it, is the source of perhaps the most profound satisfaction known to man. Such workers, it is true, are the exception ; but even the mass of men, the men who perform the typical work of the community, are probably far happier with their work than they would be without it. It is in many cases only the last hour or so in the day's labour which is positively unpleasant to the average man or woman. These considerations, however, do not imply that there are no real costs underlying the performance of labour. The unpleasantness of that last hour of work, the irksomeness, monotony, and danger involved in many occupations, even the sacrifice of leisure pursuits, are " real " costs of a very substantial nature.

Can it be said, then, that money costs measure " real " costs ? That is to say, if one commodity costs 10s. and another 20s. to produce, can we say that the latter involves twice as much sacrifice on the part of those who have contributed to its production as the former ? A moment's reflection will show that we certainly cannot.

In the first place, we have no means of comparing different individual experiences. How, for example, can we compare the pain or sacrifice involved in the day's work of an agricultural labourer with that involved in the day's work of a miner ? All that we can say is that in so far as the workers have free choice they will sort themselves out among the various occupations according to their individual preferences, after making due allowance for the rates of pay and the conditions prevalent in each occupation. In the second place, money cost has no necessary connexion with pain cost. The fact that a lawyer earns ten or twenty times as much as a miner does not signify that he undergoes ten or twenty times as much pain in the performance of his work. The better-paid work is usually the more congenial. Moreover, the pain involved in work is not the only real cost involved in production. There is also the sacrifice involved in the supply of capital. If it is difficult to compare the sacrifice or pain involved in different kinds of labour, it is impossible to compare the sacrifice of the worker with the sacrifice of the saver. How, then, can one compare the pain involved in the production of commodity A, which is the product of *a* units of capital and *b* units of labour, with commodity B, which is the product of *b* units of capital and *a* units of labour ? The truth is that one cannot make a scientific statement about the pain costs involved in production. Is it impossible, then, to go behind money costs? Must we take the money cost of a commodity as an ultimate fact which is incapable of further analysis ? In order to answer this question, shift the point of view from that of the individual and regard costs from the standpoint of the community.

Suppose that the Minister of Housing and Local Government is contemplating an extensive housing campaign. Having considered the urgency of the demand for houses, he would next consider the cost involved in increasing the supply by the number contemplated. The cost of the houses would be reckoned in terms of those other things the production of which would have to be forgone, in order that the necessary labour and capital might be transferred to housing. The production of more houses would obviously involve the sacrifice of other forms of wealth. Other opportunities of production, that is to say, would have to be forgone in order to produce more houses. This is the cost—" opportunity cost " as it is called—which the state planners would take into consideration.

Thus the real cost of any commodity which underlies its money cost of production is opportunity cost. That is to say, the real cost of a commodity consists in the alternative commodities which the community has to go without in order to obtain the commodity in question. The opportunity cost of a commodity is measured by its money cost of production.

LESSON 19

The Cost of Production Theory of Value

THE cost of producing a commodity can be regarded from three points of view. First, the business man's. To him, the cost consists in the money outlays he has to make to obtain the necessary labour, capital, land, and materials. The aggregate of these outlays comprises the money costs of production. Take as an example a car which has cost the manufacturer, say, £450 to produce. This £450 might be made up of £180 for wages, £20 for interest on the capital employed, £30 for rent, £200 for materials and components, £20 for depreciation of plant. All these outlays in the final analysis consist of payments to the original factors of production, labour, capital, and land. The first three items are direct, the last two items indirect, payments to these original factors, for the costs of materials and machinery are ultimately resolvable into payments for land, labour, and capital.

The second viewpoint is that of the individuals who supply the original factors of production. What cost does the worker undergo in giving his services, the capitalist in supplying his savings, the landowner in making available his land?

It has been seen that cost to the worker consists in the irksomeness, monotony, danger, and the sacrifice of leisure which his work involves. This is the subjective or " real " cost of the work to him. Cost to the capitalist consists in the postponement of consumption or, in other words, the " waiting " which is involved in saving. These " real " costs influence money costs, for they tend to restrict the supply of the factors of production. But as they are not proportional to money costs, " real " costs cannot be an adequate explanation of money costs.

The third viewpoint is the social one. What is the " real " cost to the community involved in the production of a £450 car ? In one sense the social " real " cost consists in the sum of the sacrifices made by the members of the community who have co-operated in producing it. To compute this cost is, however, clearly impossible. The only scientific conception of cost from the social point of view is what is known as opportunity cost, which consists in the sacrifice of displaced alternatives. Thus, the social cost of producing a £450 car consists in the sacrifice of those commodities which could have been produced by the factors of production to the value of £450.

Having analysed money costs and the ultimate facts which underlie them, we are now in a position to return to the problem of value, i.e. price. What, then, are the causes which determine the relative prices of commodities ? In the 19th century there were two principal schools of thought on this subject, namely, the cost theory of value and the utility theory of value. Until the 1870s the cost theory of value held the field as the only explanation of value. According to this theory, value is determined by costs. The reasons for this view were mainly these.

First, there is no connexion between the utility of a commodity and its value ; bread is of great utility, but of small value, while diamonds are of small utility, but high value. Second, there is a close correspondence between the cost of a commodity and its value ; producers would cease to supply any commodity of which the value continued to be below the cost of producing it ; they would increase the supply of it if the value of the commodity was above its cost. In other words, competition among producers regulates the supply of commodities, so that in the long run cost of production and price always coincide.

Shortcomings of Cost Theory

The cost theory of value, however, was not entirely satisfactory, for one cannot accept the money costs of production as final facts ; it is necessary to explain the causes which determine money costs. This school of economists, therefore, were driven back to the " real " costs which underlie money costs ; and by making assumptions which have no correspondence with reality they endeavoured to show that the money cost of a commodity is determined by the " pain " cost of the workers and the " abstinence " cost of the capitalists.

The cost theory of value did contain an important kernel of truth. For while the " pain " cost of the workers and the " abstinence " cost of the capitalists do not determine value, they nevertheless exert an important influence on it. If, for example, saving could be effected without the sacrifice involved in postponing consumption, then the supply of capital would be enormously greater than it is. Moreover, an increase in the supply of capital would have an important influence on the prices of commodities ; for example, the prices of all those goods and services the production of which requires comparatively large amounts of capital would fall relatively to the price of those goods and services the production of which requires comparatively small amounts of capital.

Similarly, the " pain " cost of labour exerts an important influence on value. Suppose that in the next hundred years inventions will have rendered all occupations equally agreeable, so that the work of the miner is no less agreeable than the work of a farm labourer. Clearly, such a revolution in the processes of production would have an important influence on the relative prices of commodities. It would no longer be necessary, as it is at present, to offer a higher wage than is offered to men of a similar grade in order to induce them to take up the occupation of a miner.

Or suppose the imaginations of men were captured by a new religion, which taught the value of work as an end in itself. What would be the effect on the value of goods and services if men were thus to become more willing to work ? Clearly, the prices of those goods and services which require a relatively large amount of labour would fall compared with the others.

These examples illustrate the element of truth contained in the cost theory of value, and this truth can be conveniently summed up in the following generalisation : *Any influence which limits the supply of a commodity tends to raise its price.* Where the cost theory of value was wrong was, first, in suggesting that the " pain " cost of labour and the " abstinence " cost of saving were the sole influences limiting the supply of a commodity ; second, in suggesting that demand had no influence on value.

LESSON 20

The Marginal Utility Theory of Value

In the preceding Lesson it was seen how until the 1870s economists were unanimous in interpreting " value " in terms of the cost theory. While differing as to the relative importance of the constituents of cost, they were agreed that value was determined exclusively by the supply side of the equation. How could the other side of the equation, the side of " utility," have anything to do with value ? Iron, it was pointed out, was of much greater utility than gold, and at the same time was of much lower value. Moreover, gold was more valuable than iron in the same proportion as its costs of production were higher. Thus, it was held, there is a strict correspondence between the cost of a commodity and its value, while utility is not commensurate with either.

Scarcity—and Demand

It was presently realized, however, that the cost theory of value had its limitations. How, for example, could one explain or estimate the value of a work of art ? It was of little use referring to the costs of producing Botticelli's " Birth of Venus." It was argued, therefore, that a different theory applied to all those things which it is not possible to reproduce. The value of works of art, it was said, was determined by their scarcity in relation to the intensity of the demand for them. And this apparent deficiency of the cost theory, it was argued, was not serious, since we are mainly interested in the value of those goods which are freely reproducible.

Even in the case of freely reproducible goods, however, the theory soon proved unsatisfactory. How, for example, could it account for the fact that a gallon of French burgundy is more valuable than a gallon of Australian burgundy? The labour involved in the production of the French burgundy is less highly paid than the Australian labour, and the expenses of the fixed and circulating capital are approximately the same in both cases. The explanation is, of course, that the land comprising the French vineyards is scarcer and of a different composition and exposed to different climatic conditions from those of the corresponding land in Australia ; the French vinegrower has to pay more rent. But the higher rent of the French vineyards cannot be accounted for by any theory of costs. Land cannot be produced like machines.

Jevons's Theory of Value

In 1871 W. S. Jevons (1835–82) startled the economists by putting forward his marginal utility theory of value ; this theory asserted that utility and not cost is the fundamental cause of value. The error of previous theories, said Jevons, is due to the fact that economists have paid attention to only one aspect of utility, namely, the *total* utility of a commodity. But, once we recognize the distinction between the total utility and the utility of a small unit of any commodity (i.e. the marginal utility), the fundamental influence of utility on value will be admitted.

Definition of Marginal Utility

Jevons stated that we could theoretically divide our supply of any commodity, say, water, during any period of time into a number of portions. The utility of the first portion, if we were deprived of the other portions, would be infinitely great ; the second portion would have a slightly smaller utility, and so on until we arrived at the last or marginal portion, which would have the least utility of all. According to this theory it is the *final utility*, as Jevons called it, or " the marginal utility," as it is generally called to-day, that determines value.

Shortcomings of Jevons's Theory

" Value," said Jevons, " depends solely on the final degree of utility," since the utility of the marginal unit of any commodity determines the value of all the other units. For example, the first portion or unit of our food supply is obtained at the same price as the marginal unit, and the price of the marginal unit is equal to its marginal utility. This coincidence of marginal utility and price is obtained by the action of consumers who endeavour to spend their incomes to the best advantage. Jevons, however, was as one-sided and inadequate in his explanation of value as were the economists who upheld the cost theory. To show that marginal utility coincides with price is one thing, to show that marginal utility *determines* price quite another ; the cost theory had been equally successful in showing that the cost of a commodity coincides with its price.

Beginning of Modern Economics

Nevertheless, the marginal utility theory was an important step forward in the development of Economics. By introducing the conception of the margin, it laid the foundation stone of the modern developments of economic theory. One of the most important of these developments has been the emergence of a sound and comprehensive theory of value. In the modern theory cost is no longer regarded as independent of utility, as in the cost theories; a single cause is no longer given as a sole determinant of value, as in the marginal utility theory. On the contrary, it is now seen that costs cannot be explained without reference to utility, and utility cannot be explained without reference to costs.

Value arises from the contrast between tastes and obstacles. On the one hand, there is the material environment in which man lives, as well as his ability and reluctance to utilise it. On the other hand, there are the various ends of man which occasion his desire for wealth.

Contrast of Tastes and Obstacles

The interaction of man's tastes and the obstacles that he encounters in satisfying them determine the ratio in which things exchange for one another. By way of illustration—why are Paris gowns more expensive than gowns made elsewhere ? The Parisians, possessed of superior taste and skill in dress designing, produce gowns which women regard as superior to other gowns. But the number of Parisians who possess this superior taste and skill are few in relation to the demand for their services. This scarcity of highly skilled labour causes keen competition for its use, thereby forcing up its price, and the high price of the labour engaged in their design and fabrication raises the cost of Parisian gowns.

Any attempt to explain value, therefore, solely on the cost side of the equation or on the side of utility is doomed to failure. Costs cannot be explained without reference to utility. Nor can utility be explained without reference to the obstacles encountered in the production of commodities. For the extent of these obstacles determines the extent to which a particular desire can be satisfied. And this latter circumstance affects marginal utility.

LESSON 21

Distributing the Product of Industry

TURNING to the other aspect of the problem of value, namely, that of distribution, the question which arises for discussion is: What determines the value of the services of labour, capital, and land? As in the case of commodities, the values of labour, capital, and land are obviously determined by the interaction of the influences underlying the demand for, and the supply of, the various factors of production. In our analysis of distribution, however, we shall not deal with the influences underlying the supply of these factors. We shall take the supply as given. This omission is made partly for the sake of simplicity and partly because the supply of labour and capital is determined by influences which do not lend themselves to economic analysis.

Supply of Factors of Production

The supply of labour, for example, does not depend on the price offered for the services of labour, as the supply of motor cars depends on the price offered for motor cars. It depends partly on the size of the population and partly on the number of hours which each individual works. The size of the population depends on such factors as the status of women, the dissemination of information on birth control, the infant mortality, the desire of parents to have children, the financial cost of having a baby, the popularity of motor cars, and so on—all of which are factors outside the scope of Economics. Even the length of the working day is determined by custom and by authoritarian control.

The supply of capital is also largely determined by non-economic factors. Perhaps the most important of these factors is the attitude of business men to the firms they control, which in many cases they regard as ends in themselves. Because of this attitude business men put back profits into their businesses without balancing the sacrifice involved against the possible gain.

On the other hand, the supply of the remaining factor, land, does not give rise to a problem at all, as it is fixed for all times.

Influences on Demand

Our problem, therefore, of ascertaining the principles on which the national income is shared among the three factors which co-operate in its production, consists in analysing the influences underlying demand. As far as demand is concerned, the principles which determine the value of land, labour, and capital are precisely the same as those which determine the value of commodities. For the entrepreneur stands in the same relation to the factors of production as the consumer stands to consumable commodities. It is the entrepreneur who purchases the services of the factors of production, and he—like the consumer—endeavours to obtain the maximum return from his expenditure. His constant endeavour is to combine land, labour, and capital in such proportions as to leave the widest possible margin between the expenses he incurs and the price he gets for his product. If, for example, the entrepreneur is a farmer, he will endeavour to hire just so much land, just so much capital, and just so much labour as will make the most economic combination. Similarly, the consumer purchases just so much food, clothing, house-room, beer, tobacco, etc., as will yield him the maximum return in satisfaction.

Thus the problem for the entrepreneur is essentially the same as that for the consumer, namely, the economic management of resources. As previously explained, two fundamental principles must be observed if resources are to be managed to the best advantage—the principle of price and the principle of diminishing utility. The consumer does, in fact, spend his income in accordance with these principles or laws.

Price and Diminishing Utility

The consumer observes the Law of Price by expending his income according to the terms on which the various goods and services are available. The housewife, for example, who is confronted with a rise in the price of tea may transfer a part of her expenditure on that commodity to coffee, etc. Similarly, the entrepreneur who is confronted with a rise in the price of labour may transfer a part of his expenditure on labour to capital or land. For, just as the housewife can substitute at the margin other things for tea, so the entrepreneur, while he is unable to do without labour altogether, can substitute at the margin capital or land for labour. This capacity of the factors of production to act as substitutes for one another is of great importance.

If the entrepreneur, however, is to obtain the maximum return from his expenditure on land, labour, and capital, he must also observe the Law of Diminishing Utility. This law, it will be remembered, in its application to the expenditure of consumers, is to the effect that the utility to us of a commodity diminishes with every addition to our stock of it. The consumer observes this law by trying to buy only so much of each commodity as will cause its marginal utility to him exactly to coincide with its price. Thus, in expending his income, the consumer takes no account of the total utility to him of the various commodities.

Similarly, the entrepreneur takes no account of the total utility of land, labour, or capital ; but it is the marginal utility of these factors of production which tends to coincide with the price he is prepared to pay for them.

An important distinction should be noticed between the utility of a consumable commodity and the utility of a factor of production. The utility of a consumable commodity depends upon its capacity to satisfy human desires ; the utility of a factor of production depends on its capacity to produce commodities, or, as expressed in Economics, on its productivity. Thus the utility of bread depends upon its capacity to satisfy the wants of our stomachs, but the utility of a plough or an agricultural labourer depends on its or his capacity to contribute towards the production of food. Instead of speaking, therefore, of the utility of labour, capital, or land, we speak of their productivity.

How Much by Each ?

In order that the problem of distribution of the national income may be solved on settled principles, it is necessary that the contribution of the various factors of production should be ascertainable. If it is not possible to ascertain the specific contribution of each factor to the finished product, then, clearly, the share of each contributing element cannot be determined on scientific lines.

Many economic writers are of the opinion that the problem of determining the specific contribution of each factor of production is an insoluble one. Thus George Bernard Shaw (1856–1950) asserted in *The Intelligent Woman's Guide to Socialism and Capitalism* (published 1926) that

> When a farmer and his labourers sow and reap a field of wheat, nobody on earth can say how much of the wheat each of them has grown.

It is necessary to become familiar with the principle of substitution on which the marginal analysis of distribution is based. The meaning of this has been clearly put thus :

> He (the employer) is continually comparing the efficiency and the cost of different ways of obtaining his object. He is always looking for new suggestions, watching the experiments of others and trying experiments himself, so as to hit upon the combination (of land, labour and capital) which will yield the largest incomings in proportion to any given outlay; or, in other words, he is ceaselessly occupied with the principle of substitution.

Clearly, however, this principle of substitution depends on the interchangeability of the various factors of production. For example, a farmer can till his land by employing a large number of labourers and setting them to dig, or by using a tractor plough with one man to drive it. Similarly, capital can be substituted for land. The London underground railways are an example of the possibility of substituting capital for land, for the capital sunk in the tunnels is virtually a substitute for the land which would have been necessary if the railways had been built on ground level.

Substitution of Factors of Production

Thus land, labour, and capital compete with one another for employment. To see how this competition works in practice, suppose that an entrepreneur is setting up a shoe factory. How will he set about it ? He knows that he will have to hire some land, to borrow some capital, and to employ some labour. The questions he has to solve are—how much land, how much capital, and how much labour, since, as we have seen, they can be substituted for one another, not in totality, but at the margin. For example, when he is deciding on the size of the factory he will erect, he has the alternative of buying a relatively large area of land and building thereon a one-storey factory. In this case he will spend more on land by economising on capital. Or he may decide to erect a high building on a relatively small area. In this case he will economise on land by erecting a more expensive building, requiring deeper foundations and stronger walls.

When he has erected his factory, he will next have to decide on the machines and the various labour-saving devices to be installed, as well as on the number of his employees. Here, again, he will find that the factors of production compete with one another. He can install relatively more labour-saving machinery, thereby dispensing with a certain amount of labour ; or he can decide on a relatively large staff, and economise on machinery.

Marginal Productivity

On what principles will he determine the amount of the total available resources which he will expend on land, labour, and capital respectively ? The principles are the same as those which operate in the case of the business man and in the case of the housewife, namely the Law of Price and the Law of Diminishing Utility. As regards the Law of Price, the entrepreneur will obviously devote more of his resources to labour if wages are low than if they are high ; and more to capital if he can borrow money cheaply than he will if the rate of interest is high.

The other factor which will determine his decision is the relative utility—or, rather, productivity—of labour and capital for the purposes he has in view. But just as in the case of commodities it is the marginal utility that is significant, so in the case of the factors of production it is the marginal productivity which influences the demand of business men.

LESSON 22

The Law of Diminishing Productivity

CORRESPONDING to the Law of Diminishing Utility is the Law of Diminishing Productivity. The former asserts that the utility to us of a given unit of a commodity diminishes with every increase in our stock of it. If you possess five pairs of shoes, an additional pair will have less utility for you than if you possess only one pair. Correspondingly, the Law of Diminishing Productivity asserts that after a certain point the productivity of a given unit of a factor of production decreases with every increase in the supply of that factor. A farmer employing twenty labourers, for example, would find that an additional labourer would increase the produce of his farm by a smaller amount than would be the case if he were employing only fifteen labourers. The farmer would also find that the Law of Diminishing Productivity applies in exactly the same way to land and capital.

To see how the Law of Diminishing Productivity works out in practice, take as an example a farmer who has emigrated to the great wheat belt in North America. In the first year he works single-handed except for the assistance of his family, and produces a crop of wheat of a certain amount. In the following year he has enough money in hand to hire a labourer, with the assistance of whom he is enabled to treble the amount of his crop.

Thus he finds that the extra sum of money which he obtains from his larger crop exceeds by a large margin the wage he pays to his man. He is therefore encouraged to take on a second worker. He can now cultivate his land still more intensively and can harvest his crop still more rapidly. As a result of the co-operation of the second worker, his crop may possibly be increased by a greater amount than was the case when the first worker was taken on. That is to say, although he has only doubled his staff, he may have increased his crop threefold. He might even find that by doubling his staff again in the following season his crop was again more than doubled.

Clearly, however, a point must be reached when his produce will increase by a smaller proportion than the increase in his labour force. Thus he may find that when he has raised his staff to ten, the Law of Diminishing Productivity begins to assert itself. That is to say, if at this point he increases his staff by one-tenth, i.e. by one man, his produce will increase by less than one-tenth, and so on.

It is a law which is almost as self-evident as the Law of Diminishing Utility. Suppose for a moment that it did not operate. Then if, in the example taken, the farmer found that he could go on increasing his staff indefinitely without diminishing the productivity of each additional labourer, it would be possible to raise the wheat supply of the world from this single farm ; and, as there would be an enormous saving in rent, it would be profitable to do so.

The Law of Diminishing Productivity applies throughout the whole field of production. Take as an example a cotton mill with a given quantity of spindles and other equipment. It is obvious that, as in the case of the farmer, the increase in the output of the mill would in the early stages of hiring operatives increase in greater proportion than the increase in the number of operatives, but after a certain point the output of the mill would increase by a smaller proportion than the increase in the number of operatives.

LESSON 23

Marginal Theory and Factors of Production

TO understand the process by which the earnings of the factors of production are equated to their respective productivities, reference can be made again to the example of the farmer which served in the preceding Lesson to illustrate the Law of Diminishing Productivity. The hiring of the first labourer by the farmer resulted in an increase of produce by an amount much greater than the labourer's wage ; similarly with the second, third, and fourth labourers. A point is reached after which the advantages—such as division of labour and the better organization—which are derived from increasing the labour on the farm begin to be offset by the disadvantages of cultivating the land more intensively. That is to say, after a certain number of labourers have been taken on, the hiring of an extra labourer would increase the produce by a smaller proportion than the increase in the number of labourers ; and this diminishing productivity will continue progressively.

The problem is to ascertain the exact point at which it will no longer pay the farmer to hire an additional worker. Clearly, it will no longer pay him to add to his staff when the hiring of an additional labourer would not increase the produce by an amount sufficient to pay his wage. Suppose that the farmer takes on a tenth worker, as a result of which his crop is increased by 100 bushels. If the price he gets for the extra 100 bushels is less than the wage he has to pay, then it will not be profitable to him to retain the tenth worker. If the price he gets for the extra 100 bushels exceeds the extra wage he has to pay, then he will retain the tenth worker, and possibly take on an eleventh man.

Marginal Productivity and Price

Thus, so long as the value of the product of an additional worker exceeds the wage he has to pay, it will be profitable to the farmer to increase his staff. The conclusion is that if he is to maximise his profits he must hire labour up to the point at which the productivity of the marginal labourer is just equal to the wage he has to pay.

So far we have worked out the productivity theory of distribution in its bearing upon labour. But the same principles determine the share of the other two factors, land and capital. In hiring land or capital, the farmer or entrepreneur will find that after a certain point has been reached the productivity of these factors will diminish. For example, when the farmer has equipped himself with the more essential farm buildings, implements, etc., he may well find that the investment of a further £100 on equipment for his farm will yield, as in the case of labour, a less than proportional return. This diminution in the productivity of the capital he borrows will continue progressively. A point must be reached, therefore, when it no longer pays him to borrow or hire additional capital at the current rate of interest. This point will be reached when the increase in output, due to the marginal £100 which he adds to his equipment, is just equal to its cost—i.e. to the rate of interest he has to pay for it.

As exactly the same argument applies to the hiring of land, an important generalisation can be made about the value of the factors of production : *In any given economic situation the value (i.e. the price) of an addition to each factor of production tends to equal the separate contribution of that addition.*

Total Value and Profit

Since the entrepreneur's expenditure on each factor tends to stop at the margin, i.e. when its productivity equals the price to be paid, all the units of labour, capital, and land employed should have been hired for less than his estimate of their value to him, and should therefore have contributed to the total producer's surplus of utility or value. If the entrepreneur's estimates have been correct, the total value of the product will be greater than the amounts he has to pay for the labour, capital, and land employed, the difference being his profit. This is his remuneration for risk-taking and for organizing.

Chiefly because the price of the product is usually determined some time after the price to be paid for the labour, capital, and land is fixed, it is possible for the entrepreneur to estimate wrongly the value to him of the contribution of these factors, and for the total amounts paid to them to exceed the eventual value of the product. When that is so, there is a loss to him instead of a profit.

What is the marginal productivity depends on the unit price of the product. A rise in the unit price raises the margin, that is, makes it profitable to use factors (lands, labour, or capital) that were formerly below the margin. For example, a glazier who is to be paid 4s. an hour and who can put in 12 panes of glass an hour is unemployable while the price received per pane is less than 4d.; if the price per pane rose to 6d., a man able to glaze only 8 panes an hour would be " on the margin."

Earnings of Marginal Factors

The tendency for the earnings of each marginal factor to equal its contribution to the product of industry is of the greatest importance from the social point of view. It means that each factor tends to find that position in the industrial organization in which its effectiveness is at a maximum ; that is to say, the position in which its contribution to the social income is maximised. This is due to the endeavour of each entrepreneur to distribute his resources in the most economical manner. The consumer endeavours to spend just so much on each commodity as will maximise the satisfaction he obtains from his income ; so the entrepreneur endeavours to expend just so much on land, labour, and capital respectively as will maximise the return from his total outlay The entrepreneur has a criterion of the success of his efforts which is strictly analogous to that of the consumer. The consumer, as we have seen, derives the maximum satisfaction from his income when he has brought the marginal utility of each commodity to him into coincidence with its price. That is to say, he adjusts his expenditure so that over a substantial period, say a year, the marginal shilling which he spends on each commodity (i.e. the shilling which he is only just induced to spend) will yield him equal satisfaction.

Has the entrepreneur an analogous criterion as to the expenditure of his resources to the best advantage ? Clearly, in order to maximise the profit from his expenditure on land, labour, and capital, he must distribute his resources in such a way that the marginal pound he devotes to each factor yields him an equal return. If the marginal pound, the pound which he is only just induced to expend on machinery, yields him a lower return than the marginal pound which he expends on labour, then he can increase the aggregate return from his resources by transferring part of his resources from the hiring of capital to the hiring of extra labour. Thus the entrepreneur is constantly endeavouring to adjust his expenditure on the factors of production so that the marginal productivity of each factor is not less than its price. In so far as he is successful, he maximises not only his own profit but also the earnings of the factors, as well as their contribution to the social income.

LESSON 24

The Economic Aspect of Rent

It is necessary to be quite clear about the meaning of terms—what is meant by land, and what by rent, the payment that is made for the hire of land. When one talks of agricultural land, one has in mind fields of corn and vegetables, meadows and orchards. This agricultural land is not land in the strict sense at all, but a combination of land and capital. By the cornfields, the meadows, and in various other ways, the land has been improved by the expenditure of capital. A landowner will therefore expect from his tenants not merely remuneration for the land itself but also for the capital he has sunk in the land. It is customary to speak of the whole payment which the farmer makes to his landlord as rent, but, strictly speaking, it is partly rent (the payment for the land without improvement) and partly interest (the payment for the improvements). Land can be defined, therefore, in the terms of the classical economist David Ricardo (1772–1823), as the inherent and indestructible powers of the soil. Thus rent, in the strict sense, is the payment made for the use of the inherent and indestructible powers of the soil.

The problem of rent presents two main questions. Why is the average level of rent what it is? And why is the rent of some pieces of land higher than the rent of other pieces? The first question is concerned with the scarcity aspect of land; the second question, with the differential aspect.

Scarcity Aspect of Land

To simplify our analysis of the scarcity aspect of land and to place it in its true perspective as the fundamental aspect, we shall assume that the quality of all land is precisely the same. This simplifying assumption having been made, the first question that presents itself is: Why does the farmer not get his land for nothing? Land, being a free gift of nature, has not cost anything to produce. The answer, of course, is that land is scarce. There are certain stages in the development of communities in which land is not scarce, and in which, consequently, the problem of rent has not emerged. In order to understand the causes which determine the scarcity of land, suppose that a party of colonists settles on an uninhabited island of uniform fertility, and then let us observe how land comes to command a rent. In the first stage of colonisation each man will have all the land he requires; there is enough for all and to spare. He will therefore cultivate that amount of land which will yield the maximum return to his labour and capital. Land being free, there will be no incentive to economise in its use. As the population increases, however, more and more men will settle on the land, until a stage is reached when the amount of land available is no longer sufficient to satisfy the requirements of all. The cultivators will then begin to compete for the fixed supply of available land.

Suppose that the land of our imagined island is free and unappropriated. So long as the number of applicants for the available plots does not exceed the number of plots available—twenty of each, say—the plot holders will make no payment for their land. But suppose that the number of applicants grows to twenty-one. Then the twenty-first applicant will be obliged to offer some consideration—some payment—to one of the owners or occupiers, for a plot or part of a plot. The payment he makes will constitute rent. By means of such payments the demand for land will be equated with the available supply.

This emergence of the factor of rent will have important reactions on the methods of cultivation. The farmers, now that they have to pay for the use of their land, will find it profitable to economise in their use of it; that is to say, they will now cultivate it more intensively. More capital and labour will be applied to the cultivation of each acre than formerly. Thus the farmer will find himself confronted with a new problem: that of how much more intensively he shall cultivate his land.

Let us take an arithmetical illustration. The return to successive applications of capital and labour to land must diminish according to the Law of Diminishing Productivity. Suppose, then, that the first £100 of capital and labour yields a produce of 1,000 quarters of wheat, the second £100 yields 800 quarters, the third £100 yields 500 quarters. As long as the land was free no farmer would expend more than £100 on each acre of his land ; for if he were to expend a second £100 on any acre of land, he would obtain a smaller return than he would do if he took into cultivation an additional acre of land, since (in our illustration) the application of a second £100 on any particular acre would yield only 800 quarters, while the application of this £100 to an additional acre of land would yield 1,000 quarters.

Different plots of land vary in their suitability for a particular use. Thus, a farmer may have two adjacent fields of equal size whose suitability for growing wheat may differ so much on account of the aspect, nature of soil, etc., that if treated identically one field might produce 50 bushels more than the other. The better field offers to the user a differential gain equal to the price of the extra bushels. The owner of the field may know this fact, and may ask the prospective user a rent which is greater than that he requires for the poorer field. The rent will be such proportion of the differential advantage (50 bushels of wheat) as he can induce the farmer to pay. Similarly, two building sites for shops may be of precisely the same size, but one, because of its situation, may offer to the prospective shopkeeper the promise of many more sales. The better site will attract the higher rent, which will tend to embody the differential gain of the user. Observe that such economic rents arise out of the inherent difference between a certain piece of land and other land on the margin of use, that is, land just usable without loss. Observe, too, that if the price of the product rises, the differential gain of a particular plot will increase also : rents tend to increase as prices increase.

LESSON 25

Malthus and the Population Problem

With the economic development of any particular country, population grows and land becomes increasingly scarce. More and more food is required to feed the growing population, while the development of the towns encroaches on the available agricultural land. Hence there is an ever-increasing incentive to economise land. In agriculture farming will be ever more intensive ; in the towns the buildings will tend to become higher. This concentrated use of land will mean that, other things being equal, the return which it makes in response to human effort will decline and the community will become impoverished. In accordance with the Law of Diminishing Productivity, an increasingly smaller return will be obtained from the application to land of additional units of capital and labour.

Hence, if other things remain the same—that is to say, if there are no new inventions, if there is no improvement in economic organization, if the supply of capital does not become relatively more abundant—then an increase of population must reduce the standard of life. This is the first of the two main aspects of the population problem, namely, the influence the size of the population exerts upon the productivity of human effort. The other aspect of the population problem is concerned with the causes which determine the size of the population.

The population controversy, in its modern form, began with the publication in 1798 of the first edition of the *Essay on the Principles of Population as it Affects the Future Improvement of Society*, by T. R. Malthus (1766–1834). In this book Malthus was concerned to point out not only that the population problem would wreck an equalitarian society, but that this problem is an ever-present one ; that is to say, Malthus maintained that population is ever pressing on the means of subsistence, and always has done so. For while, he argued, subsistence increases in an arithmetical ratio (1, 2, 3, 4 . . .), population is capable of an increase in geometrical ratio (2, 4, 8, 16 . . .), and would, in fact, increase at this rate, were it not for the existence of checks, which are either positive—unwholesome occupations, severe labour and exposure to the seasons, extreme poverty, bad nursing of children, large towns, excesses of all kinds, the whole train of common diseases and epidemics, wars, plague and famine—or preventive—moral restraint (not the same thing as " birth control ") and vice. " Through the animal and vegetable kingdoms," he wrote, " nature has scattered the seeds of life abroad with a liberal hand, but has been comparatively sparing in the room and nourishment necessary to rear them."

Influence of Malthus

The writings of Malthus on the population problem exerted an enormous influence in the first half of the 19th century. Not only did he convince the greater part of the influential people of that time that the problem of population hovered threateningly on the horizon, but also that population actually was pressing on the means of subsistence. Nor was he without substantial evidence to support his gloomy conclusion. Population was growing at a prodigious rate and, indeed, continued to do so throughout the 19th century. In the period 1801 to 1901 the population of England and Wales increased from under nine millions in 1801 to 32·5 millions in 1901. On the other hand, food supplies, at the time when Malthus was writing, were failing to increase in like proportion. Bread, the staple diet of the masses, rose alarmingly in price. Wheat, which was 34s. 7d. per quarter in the decade 1771–1780, rose to 83s. 11d. in the decade 1801–1810, to 87s. 6d. between 1811 and 1820.

Towards the middle of the century, however, the forebodings of Malthus faded more and more into the background. The effects of the Napoleonic wars had spent themselves, and the era of Victorian prosperity had begun. With the development of the railway and the steamship, first wheat and then meat and other foodstuffs poured into Great Britain from the newly developed continents in greater and greater quantities, and at lower and lower prices. Indeed, so great was the influx of food that the agricultural industry at home suffered serious depression.

Revival of Malthusian Theory

The first note to disturb this era of Victorian confidence was sounded by Sir William Crookes (1832–1919) in his celebrated address at the annual meeting of the British Association in 1898. Said Sir William :

> All civilized nations stand in deadly peril of not having enough to eat. As mouths multiply, food resources dwindle. Land is a limited quantity, and the land that will grow wheat is absolutely dependent on difficult and capricious natural phenomena. I am constrained to show that our wheat-producing soil is totally unequal to the strain put upon it.

Thus the Malthusian devil was unleashed once more. During the decade which preceded the First World War the view taken by Crookes became more and more prevalent in authoritative circles. For population was still increasing rapidly in all parts of the world ; the continents of America, Australia, and Canada, which were rapidly filling up, were requiring a greater and greater proportion of their food production, on which Great Britain was very largely dependent.

It was not until after 1918 that the alarm became general. In 1919 Lord Keynes, in his book, *The Economic Consequences of the Peace*, viewed the position as follows :

> The essential facts of the situation, as I see them, are expressed simply. Europe consists of the densest aggregation of population in the history of the world . . . The danger confronting us, therefore, is the rapid depression of the standard of life of the European populations to a point which will mean actual starvation for some . . .

Thus, during the last century and a half authoritative opinion on the food problem has swung first one way and then another. Up to the 1840s Malthus had demonstrated that population was pressing on our food supplies ; with the rise of Victorian prosperity and the development of the new continents this pessimism passed away, to reappear once more in the 20th century.

Recent Advances in Agriculture

Great advances have been made in agricultural technique, in plant genetics, in agricultural engineering, and in the production of artificial fertilizers. But will the increased capacity to produce food suffice ? Medical science has removed some of the checks on the growth of population, so that in the 1950s fewer people died prematurely and many lived longer than people did a century ago. West European populations are increasing steadily ; those of America and, even more, Asia are growing very quickly. Each day some millions are added to the mouths to be fed. Intensive cultivation may enable world food production to keep pace with and even outstrip the increase in world population ; but this cannot be taken for granted. For example, the food problems of Japan, with a population approaching 100 million in a cultivable area smaller than that of the United Kingdom, are exceedingly grave ; the Japanese can survive only through trade, or emigration, or a drastic limitation of births.

J. S. Mill (1806–73) shared the view of his predecessors that increases of population are, in general and after a point, an economic evil. He assumed that the great innovations of the 19th century—the railway, the steamship, the development of power production and electricity—could have taken place without the stimulus of an increasing population ; he seemed unable to realize that these inventions required an increase of population if they were to be effectively utilised.

Population Problem and the Optimum

Henry Sidgwick (1838–1900) was the first writer to place the population problem in its true perspective. He showed clearly for the first time that not only does productivity per head not diminish until population has reached a point of very considerable density, but also that this point is continually fluctuating according to the state of industrial technique, the rate of savings, and other relevant circumstances. This line of thought was developed by Edwin Cannan (1861–1935), who introduced the idea of optimum population—the population which is neither too small nor too large, but just right.

In order to follow this line of thought, it is necessary to realize that all changes in the size of the population set up counteracting tendencies. An increase of population results in a more intensive cultivation of land already cultivated, and a resort to less and less fertile soils ; also, the greater the size of the population, the greater will be the pace at which the more accessible and easily worked mines and oil resources will be exhausted. Both these tendencies make for a reduction in productivity per head, and therefore tend to lower the standard of living. On the other hand, a larger population enables important economies in production to be introduced. In the first place, it facilitates greater specialisation ; and an increase in specialisation not only increases the efficiency of the worker, but also enables the special aptitudes of a region or country to be exploited more fully.

LESSON 26

Savings and Investment

TIME plays a fundamental role in production. In some cases the process of production is short ; in others it is comparatively long ; but in all cases production takes time. To take an example : in order that a farmer may bring wheat to market next year, it is necessary that he should prepare the soil and sow the seed this year. It is also necessary that he should harvest the wheat and thresh it before he will be in a position to bring it to market to get the return for his labour and recoup himself for the expenses he has incurred ; that is to say, he has to maintain his workers and himself, and pay for his seed during the time that elapses before his produce is ready for market. In order that he may be in a position to do this, either he or someone else must previously have consumed *less* than their purchasing power entitled them to do. In other words, in order that the farmer may be provided with the necessary capital to tide him over this intervening time period, either he or someone else must have saved. If the farmer himself has not saved the necessary amount, then he must either borrow it direct or, as happens in most cases, through the medium of the banks.

Thus the element of time involved in production is provided for by saving, or " waiting," as economists often prefer to call it. As Professor Sir Hubert Henderson (1890–1952) put it in *Supply and Demand* :

> It is not enough that the farmer and his labourers should work ; no less essential is it that someone should wait. The farmer must wait until he has sold his crops, both for the reward of his own labour and for the repayment of the wages he advances in the meantime to his labourers. Or, if he cannot afford to wait, and borrows in anticipation of the harvest, then the lender must wait until the farmer, having sold his crop, is able to repay him. Thus the period of time involved in all production gives rise to a demand for waiting which is the essential reality underlying the phenomena of capital and interest. It is really this which constitutes an independent factor of production distinct from labour and nature and equally necessary.

Waiting, however, is not only essential for the provision of circulating capital. The provision of fixed capital is equally dependent on waiting. When, for example, the farmer purchases a new tractor, either he or the lender (if he borrows the money) must " wait " until he can recoup himself from the sale of the crops the tractor enables him to produce. Or take the case of a man who purchases a house for £4,000. He lays out the money when he requires the house, but many years elapse before it yields him £4,000 worth of services. During this period he must wait.

A person is said to save when he refrains from spending a part of his income. If a man has an income of £500 a year and he spends only £300, he will save the balance of £200. The savings of the community consist of the sum of the savings of individuals. Thus the annual national savings in any year equal the sum of the differences between the money incomes of individuals, including companies (which are legal persons), and their money expenditure on consumption. The total savings constitute the amount available for investment.

Saving—and Hoarding

Saving is in itself no more than a negative act. In order that saving may become embodied in some form of capital it is necessary that someone should make use of the money that is saved. The various institutions which make up the financial system of the country facilitate this process of the conversion of savings into capital. Thus for the provision of the bulk of the circulating capital required by the business world, the banks are responsible ; when a person decides to keep a cash balance of £50 at the bank he is virtually providing the community with circulating capital, for the bank is enabled thereby to extend its loans to business men.

While the banks are mainly responsible for the supply of circulating capital, the issuing houses, insurance companies, and other " institutional investors " are mainly responsible for the supply of fixed capital.

The rate of investment does not necessarily correspond to the rate of saving. This fact is notoriously obvious during a trade depression, when capital accumulates in the banks. It is this excess of saving over investment which is the immediate cause of a decline in business activity and consequent unemployment. For the savings which would normally be spent on building factories and ships, on producing machines and the various forms of material equipment, run to waste in the banks. This is because business men are so uncertain about the future that they are unwilling to undertake new enterprises, however abundant and cheap the supply of capital may be. In "normal" circumstances, however, the rate of investment keeps in step with the rate of saving. To maintain this harmony between saving and investment is (in Great Britain) one of the chief functions of H.M. Treasury, working through the Bank of England, the Budget, and taxation and financial policy.

Savings of the British People

In a normal year the people of the U.K. save many millions of pounds. This means that each year sees an increase in the stock of factories and plant, of electricity generating stations and the means of distributing the current, of ships and the means for building ships, as well as of the necessary raw material for utilisation by these increased instruments of production. In a word, the millions of pounds saved annually become embodied in fixed and circulating capital. The people who save make their savings available for investment either by accumulating money in the banks or by purchasing shares. This, however, is merely the financial side of saving and investment. What is the actual effect on the economic system when a business man invests money in new plant and machinery? In order to avoid the complications of the industrial system, let us take the simplest possible case, by observing how Robinson Crusoe saved and invested. When Crusoe landed on his island, he at first maintained a hand-to-mouth existence by gathering nuts and fruit. To improve his position it was necessary that he should adopt some sort of civilized production—cultivation of the soil, fishing, and so forth. How was he to set about it?

Crusoe's Alternatives

In order that he might fish, he had first to provide himself with a canoe and a net; and the construction of those things took time. He had to save (food). This he could achieve in any one of three ways. We will suppose that he could build the canoe in 240 hours, and that he was in the habit of working ten hours a day and six days a week, thus requiring a working month to complete his canoe. The first course open to him was to go on gathering nuts and fruit for ten hours a day, putting aside a portion each day until he had accumulated a sufficient store to maintain himself for a month while he was building the canoe. The second possibility was for him to lengthen his working day. In this case he could maintain his consumption at the former level; the sacrifice he would have to make would take the form of a diminution in leisure. The third possibility was for him to restrict the number of hours which he spent each day on gathering nuts and fruit to, say, eight, and to devote the remaining two hours to constructing his canoe.

Savings by a Modern Community

If we assume the length of the ordinary working day to be fixed—and it is more or less fixed both by trade unions and by state regulation, as well as by custom—the process of saving in a modern community obviously corresponds to that third possibility. When a community decides to increase its savings, it does not continue to produce the same amount of consumable goods as before until it has accumulated a store of them to live on while it increases its capital equipment. If an additional £1,000,000 is saved in any year, then £1,000,000 less is spent on consumable goods. On the other hand, £1,000,000 more is spent on capital goods (i.e. material equipment) by business men to whom the additional savings have been transferred by the banks and the "issuing houses." The industries producing capital goods tend to be able to meet this extra demand, because less capital and labour will now be required in the industries producing consumers' goods.

This transfer of capital will tend to be effected by the price mechanism. The increased demand for capital equipment will tend to cause capital equipment to rise in price, while the reduced demand for consumers' goods will tend to cause the price of these goods to fall. It will therefore be profitable to transfer capital and labour from the light to the heavy industries, i.e. from the industries producing consumable goods to those producing capital goods. Thus, the first effect of an increase of saving is to reduce the output of consumable goods. The second effect is to increase the output of capital goods—an increase made possible by the liberation of capital and labour from industries producing consumable goods. The third and final effect is an increase in the output of either capital goods or consumable goods as a result of the new machines and other aids to production in which the new savings are embodied.

Result of Higher Saving

This analysis of the changes which take place in the economic system as a result of an increase of saving enables us to arrive at an important conclusion. The higher the proportion of the national income which is saved, the more roundabout the processes of production become. For savings become embodied in durable instruments of production and the raw materials which are necessary to enable these instruments to function. The more that machines and other durable equipment are used in production, the greater will be the proportion of the workers producing these machines, and the smaller will be the proportion of the workers producing things for direct consumption. But this smaller proportion of workers in the light industries will be more effective than the former larger proportion owing to the more elaborate machines which co-operate with them.

From the point of view of the community, the advantage of an increased volume of savings consists in the larger supply of commodities made available thereby. In the eyes of many people, however, this greater abundance of commodities is a curse rather than a blessing. For, it is asserted, as there is not a corresponding increase in the amount of purchasing-power available, the markets will be glutted with commodities that cannot be sold, with the inevitable consequence of unemployment. On the other hand, an increase in the volume of savings enables production to be carried on more cheaply than hitherto, since savings become embodied in equipment of various kinds, the *raison d'être* of which is to increase the effectiveness of the workers of the community. Every pound spent by business men in possessing the more efficient equipment should yield them a greater quantity of output. Hence they are able to lower their prices without trenching on their profits; and this fall in prices should enable consumers to purchase the increased supply of commodities, despite the fact that their money incomes have not increased.

LESSON 27

What Determines Wages

A WORKER'S wages do not depend entirely on his own efficiency. They depend also on his environment, which includes such factors as the amount of capital co-operating with his labour, the efficiency of his employer, and, of course, the efficiency of the economic organization in general. Anything which improves the economic environment in which he works will tend to increase his wages, for it will tend to raise his marginal productivity. An increase in the amount of capital, for instance, would mean that there would be more machines and more equipment generally to co-operate with the worker. Similarly, an improvement in the organization of an industry, or a rise in the general level of the efficiency of the managers, would tend to render the efforts of the worker more productive.

Any improvement, therefore, in the economic system of the community tends to raise the general level of wages, because it increases the income of the community. And the social income is the source from which the demand for labour is derived. Different kinds of improvement, however, affect wages differently; that is to say, some improvements tend to raise wages more than others. Thus an increase in the national income by 10 per cent. due to an increase in the efficiency of the workers would raise wages more than a similar increase of the national income caused by an increase in the amount of capital. In the first case the demand for labour would increase to a greater extent than in the second, so that a larger share of the 10 per cent. increase of the social income would go to labour than would be the case if the rise had been due to an increase of capital.

It is sometimes thought that an increase in the supply of machines and other forms of material equipment is detrimental to the worker. As machines are introduced in order to save labour, how, it is asked, can they benefit labour? The introduction of new machines in the modern world causes far less injury to the workers affected by it than it did in the early phase of industrialism. This is because the skill required by the modern worker is far less specialised than that formerly required. The skill of the modern worker consists in the skill and intelligence required to operate elaborate machines. The introduction of a new machine therefore usually requires little more than a small adaptation on the part of the worker.

The earnings of capital in the various industries constantly tend to equality. If, after allowing for differences in risk, the return to capital in one industry exceeds the return to capital in another industry, then new capital will tend to be diverted from the less profitable to the more profitable industries, until equality is approached. This process of adjustment may extend over a considerable period, as some capital takes a long time to wear out. The existence of different rates of return, therefore, at particular times, does not invalidate the assertion of a general tendency to equality. It is merely evidence that all economic adjustments encounter friction of various kinds.

Similarly, the earnings derived from work in the various occupations tend to equality. If the wages in one occupation rise relatively to wages in other occupations, labour will be attracted towards the higher-paid occupation, thus tending to reduce the discrepancy. Nevertheless, in spite of this tendency for the remuneration in the various occupations to become equal, there are permanent inequalities in the income derived from work. It is these permanent inequalities which constitute the problem of particular wages as distinct from general wages. Why does a miner earn more than an agricultural labourer? To put the question in another way, why do not the relatively high earnings in some occupations attract people away from relatively low-paid occupations ?

There are three main factors which explain the permanent differences in pay of the various occupations. First, there is the relative attractiveness of the work ; second, the cost of the necessary training ; third, the skill or natural endowment required.

" Pleasant " and " Unpleasant " Work

It is obvious that, even if the cost of training and the skill required for the various occupations were equal, there would nevertheless be differences of pay. Some occupations are more pleasant, more healthy, or less irksome than others. If the pay of agricultural workers and miners were the same, many miners would prefer to take up farm work, and the mines would be more or less deserted. The competition among the coal-owners, however, for the diminishing number of miners would then tend to force up their rate of pay. On the other hand, the competition among the increasing number of workers seeking farm work would tend to force down the pay of agricultural workers. The shift from mining to agriculture would continue until the lower rate of pay in farming was just sufficient to offset the superior attractiveness of farm work.

Training and Special Skills

Second, it costs more to fit oneself for some occupations than others. A doctor, for example, must undergo a long and expensive university and hospital training before he is qualified to practise. In order to induce him or his parents to undergo this expense, the pay offered in the medical profession is higher than that in an occupation requiring little training. It may be noted that the difference in pay may be either more or less than is sufficient to compensate for the cost of training. On the one hand, the number of people who can afford the expense of training may be so few as to create a scarcity of professional men. In Britain in the 1950s the increased number of state scholarships available was considerably increasing the number of professional men in training at the universities. The increased facilities for training will eventually lessen both the earnings differential of professional men and their prestige.

The third factor tending to produce inequality of remuneration is that some occupations require unusual skill or natural endowment. It is no use attempting to become a barrister, for example, unless one has exceptional natural endowments of a particular kind. Another case in point is the very high salaries earned by film stars. The explanation of the relatively high pay of some barristers and film stars lies only partly in the cost of training. It also lies in the scarcity of the skill or natural endowment required.

Artificial Barriers

There are, then, permanent inequalities in the incomes derived from work : differences due to three main factors—relative attractiveness of the work, cost of training, and scarcity of the necessary skill or natural endowment. These factors will probably never be eradicated so long as freedom to choose one's occupation exists. There is another factor : the creation of artificial scarcity of labour in some trades, where a rigorous control of apprenticeship restricts the number of entrants and, hence, the supply of additional labour so that its marginal utility is exceptionally high. Such restriction of entrance may be combined with what is virtually a monopoly of supply through the compulsory membership of the appropriate trade union.

Effect of Trade Unions

A trade union, if it is strongly organized, has the power to raise wages *in its particular trade*. This does not necessarily mean that trade unions have the power to raise the *general* level of wages. If, for example, the National Union of Railwaymen is successful in raising the wages of railwaymen, one cannot say offhand that the general level of wages has been raised, for the rise in the wages of the railwaymen may have been at the expense of the workers in other industries. So long as the efficiency of the economic organization remains unchanged, the general level of wages remains rigidly determined, which means that a rise in wages in any one industry can take place only at the expense of other industries. It is by curtailing the supply of labour that a trade union raises wages. If entry into a particular industry is restricted, the excluded labour will be compelled to seek employment elsewhere. In other industries, therefore, the competition for employment will be more intense, with the result that outside the favoured industry wages will tend to fall.

It has been maintained, however, that the raising of wages by trade union action will actually result in an increase in the productivity of industry. But while the immediate effect of a high-wage policy may be to create unemployment and to increase the competition for employment in other industries, the ultimate effect may be different. The high-wage policy of trade unions may well stimulate some employers to organize industry on more efficient lines. This they will be impelled to do because they will be unable to obtain their labour as cheaply as hitherto. Therefore in order to earn their former rate of profit, they will have to plan better and discover more efficient methods for running their businesses. As a result, industry will become more productive, the national income will expand, and the means for meeting the higher wages bill will be provided. The high cost of labour has been a cause of the extreme mechanisation in the U.S.A. and the consequent high productivity of American workers.

There are special circumstances in which the raising of wages has stimulated some employers in Britain to become more efficient. Governments have succeeded in bringing about permanent wage increases and vastly improved conditions in what were sweated industries. The normal reaction of an employer to a rise in the price of his labour is to dispense with a part of his labour force by substituting more labour-saving machinery ; and the introduction of more elaborate machines and other forms of equipment in response to a fixation of wages above the competitive level would result in a permanent displacement of labour.

Even though so long as the economic situation remains unchanged a trade union may be unable to raise wages except at the expense of the workers in other industries, it would not follow that trade unions ought to be abolished, for they perform highly important services both to their members and to the community. They enable the worker to obtain the full value of his contribution to industry ; they raise his wages when the productivity of industry is increasing, sooner than he would be able to do by his own unaided bargaining power ; and they safeguard his interests in other ways.

LESSON 28

The Why and Wherefore of Foreign Trade

The theory of international trade deals with two main problems. Primarily, why the production of commodities is specialised in the various countries ; why, for example, Britain imports mutton from New Zealand, and why New Zealand imports manufactured goods from Britain. Second, why countries derive greater benefit from importing the commodities they do import than if they produced those commodities for themselves.

Immobility of Labour

The principles on which the internal trade of a country is based are not dissimilar to the principles of international trade. In trade between countries, however, a new complication arises. Whereas labour is comparatively mobile within the borders of any country, it moves from one country to another only with difficulty. It is this immobility of labour *as between* countries that necessitates a special theory of international trade. An Italian, we will suppose, contemplates emigrating to America in order to take advantage of the higher wages obtaining in that country. He will have difficulties and drawbacks to contend with. He will have to sever all his social connexions and transplant himself to an alien environment—a serious consideration to most men. He will have to consider the expense of transporting himself, and perhaps his family. He will encounter the difficulty of language. In addition to these natural hindrances to the mobility of labour there are the barriers erected against immigration by different governments.

International trade may be regarded as a substitute for the mobility of the factors of production. Some countries have a relative abundance of certain factors of production—it may be a particular grade of land, such as the vineyards of France, or the wheatlands of Canada ; it may be a particular kind of skill or natural endowment of a country's industrial personnel, such as the skill and originality of British engineers. The fact that a particular factor of production is relatively abundant in any country will mean that it commands a relatively low price in that country. Wheatland, for example, is more abundant in Canada than in most countries and therefore commands a lower price there.

Redistribution or Specialisation ?

How is the world to derive advantage from the fact that certain countries possess particular factors of production in relative abundance ? In the first place, the factors of production can redistribute themselves, so that they are equally abundant, or equally scarce, throughout the world. This method is not always practicable. The great movement of labour from Europe to America and other new countries in the 19th and in the first decade of the 20th century is an example of this method, as also is the flow of capital in the same direction.

The second method is for the various countries to specialise in those commodities the production of which requires the utilisation in a higher degree of the factors which it possesses in relative abundance. Thus Canada, by specialising in the production of wheat and exporting it to England, is virtually transferring a part of her abundant wheatland to the latter country.

Suppose it were possible for Canada to transfer part of her wheatland to England. What would be the effect ? The price of wheatland, and therefore the price of wheat, would fall in England, while in Canada the reverse would happen. This, in fact, is just what took place when the interior of Canada was opened up.

Thus international trade is a substitute for the mobility of the factors of production. Looking at it from this point of view, the two main problems with which the theory of international trade is concerned are much simplified. First, why do the various countries specialise in certain kinds of production ? At first sight the answer seems obvious enough. Do not countries specialise in those commodities for the production of which they are most fitted ? In a sense this answer is correct ; but it is also misleading. A country may specialise in a commodity for the production of which it is less fitted than the country to which it exports that commodity. Britain imports dairy produce although it is quite as well fitted to produce these things as the countries which export them.

This is due in large measure, but not entirely, to the fact that Britain possesses a greater advantage in the production of those commodities which it exports as payment for these imports. The price of a country's imports is its exports. As long, therefore, as a country is obtaining its imports at a lower real cost than it could do by producing them for itself, it is deriving an economic advantage from the trade. (An *economic* advantage ; political necessity or national security may make it advisable to subordinate the economic to other factors. This has happened generally since the 1930s, countries seeking security through diversifying their industry instead of specialising in accordance with their natural comparative industrial advantages.)

Prices and Specialisation

An employer may be able to do his own housework more efficiently than his servants. Nevertheless, the employer has to specialise in the work of directing his business. For the same reason a country will profit by specialising in those commodities in the production of which it has the greatest comparative advantage. But how, it may be asked, can a country know which commodities to specialise in ? The answer is that the price indicator will direct a country's resources into those industries from which it will derive most advantage. For in any particular country those branches of industry which use efficiently a high proportion of the factors of production which it possesses in relative abundance will be able to operate at lower costs.

LESSON 29

How Imports Are Paid For

EXCLUDING the borrowing and lending transactions of a country and payment of interest on past loans, gifts and tribute to war victors, the value of a country's imports must equal the value of its exports. Over any considerable period—say, a year—the trade account between imports and exports must balance. But, the reader may remark, how can this statement be true in the face of the well-known fact that Britain imports much more than she exports ? Every year the value of Britain's imports of merchandise exceeds the value of the merchandise she exports by many millions of pounds. This is true, but it does not contradict the statement that imports and exports balance, for the simple reason that other items besides merchandise appear in the "balance of payments" of a country. A country may import or export services of various kinds. Britain, for example, is the greatest exporter of services in the world. Every year she exports shipping services ; that is to say, the British mercantile marine renders services to other countries to the value of £x millions a year. She exports banking, financial, and insurance services to the value of £y millions a year. These items in a country's balance sheet are called invisible items. But the reader may insist that even if the value of all these invisible items is added to the value of the export of merchandise, there still will be an excess of imports to the extent of some hundred millions.

True, but this excess of imports represents the interest on the large sums which Britain has invested in other countries. Before the Second World War Britain was in the fortunate position of receiving a substantial portion of her imports without having to export goods or services in return ; but most of the nation's overseas investments were used to help finance that war, and it is now necessary for Britain to export more to pay for current imports.

Since the volume of a country's imports and exports is the result of the purchases and sales of individual importers and exporters, how does it come about that these purchases and sales tend to balance one another ? In a country like Russia, where the government has the monopoly of foreign trade, the problem does not arise. If the Russian government finds that it is importing more than its exports will allow it to pay for, then it will cut down its foreign purchases. In Britain and most other countries, governmental control in the 1950s was exercised by a system of licensing, especially of the foreign exchange necessary to pay for goods ; but all the countries of the western world were trying to return to the pre-war system, when merchants were free to purchase foreign commodities on any scale they pleased, while the volume of exports obviously depended on the willingness of other countries to purchase its products. In order to understand how in these circumstances the imports and exports of a country come to balance, it is necessary to acquaint oneself with the mechanism by which payments between countries are effected.

Bills of Exchange

Debts which arise in the course of trade between countries cannot be settled in the same way as debts which arise in the course of internal trade. If a British merchant imported silks from France, he could not pay the French exporter in British pound notes or by cheque. Payments between countries are effected by bills of exchange. The French exporter, having drawn a bill on his British customer, hands it over, together with the documents which give control over the goods, to his bank, which will credit his account with the value of the goods minus the appropriate discount. The French bank then sends the bill and the documents to its London branch, or to its London correspondent, who presents the bill for acceptance to the British importer, who then obtains the documents giving him possession of the goods. The bank, having obtained acceptance of the bill, either discounts it in the London market or holds it until it matures.

" Offsetting " International Debts

The exporter's bank pays money in France to the exporter but is credited with a balance by its London branch. The same French bank may have other customers who are importing from Britain and want to make payments in London. They may arrange with their bank for the London exporter to draw bills of exchange on that bank's London branch, who will then pay the London exporter and debit the French bank for the account of the French importer. Thus the French exporter's right to receive money in France and the French importer's obligation to pay money in London may offset each other in the accounts of the London branch and in the accounts of the French bank.

It has been assumed that the imports and exports of any two countries are equal in value. This fact, however, does not prevent the process of settling international debts by offsetting ; it merely makes it more complicated.

If French merchants had been exporting much more to Britain than British merchants had been exporting to France, the French banks would, on balance, accumulate rights to receive money in London, i.e. rights to sterling. If at the same time some other country, say the Netherlands, had been importing from Britain more than it had exported to Britain, the Dutch banks would, on balance, have an obligation to pay money in London, i.e. would need sterling. In these circumstances the Dutch banks might purchase some of the sterling held by the French banks, i.e. give to the French banks a right to Dutch guilders instead of British pounds. If French merchants had been collectively importing more from the Netherlands than they had been exporting to the Netherlands, this right to Dutch guilders would help the French banks to square the account with their Amsterdam agents.

Thus, through the banks in London, Paris, and Amsterdam, the balance of imports by British merchants from France, the balance of imports by Dutch merchants from Britain, and the balance of imports by French merchants from the Netherlands, might all be offset. The money markets in London, Paris, Amsterdam, and other capitals buy and sell rights to payment in other countries as ordinary commodities are bought and sold on other markets. Consequently, in practice the offsetting process described would usually involve more than three countries.

Foreign Exchange Rates

When discussing " offsetting " in foreign trade, we saw that the money markets of the various capitals bought and sold foreign bills of exchange, i.e. rights to receive money in other countries. The prices, or rates of exchange, at which they are dealt in reflect the current supply of, and demand for, the different kinds of rights. Thus, if Britain is buying from the Continent much more than she is selling, on balance, rights to money in London become plentiful in capitals abroad, and the price tends to fall, that is, fewer francs, guilders, etc., will be given for £1. In that case British importers whose price was quoted in francs, guilders, etc., will have to pay more £s in order to get the foreign currency they need ; if the British importers' prices were stated in £s, the foreign exporters will get fewer francs, guilders, etc., and will be tempted when they sell again to quote a higher sterling price.

Since excessive importing by a country thus tends to cause that country's currency to exchange for less foreign currency, it makes foreign goods dearer and tends to discourage importing. Conversely, if Britain is selling to the Continent much more than she is buying, on balance, rights to receive money in Paris, Amsterdam, etc., become plentiful in London, and their value tends to fall, that is, those buying bills of exchange payable in Paris, Amsterdam, etc., require more francs, guilders, etc., for each £. The British exporter tends to increase a price quoted in francs, guilders, etc., in order to ensure that he gets as many £s as before for his goods. Or if the British exporter states the price of his goods in sterling, the French or Dutch importer has to pay more francs, guilders, etc., in order to get the necessary £s. In either case, goods exported from Britain become dearer to the foreigner. Rates of exchange are therefore an important corrective of foreign trade. If Britain imports excessively, the rate of exchange tends to move against the £, that is, the £ buys less foreign currency, so that foreign goods tend to become dearer. If Britain exports excessively, the rate of exchange tends to move in favour of the £, that is, the £ buys more foreign currency, so that British goods tend to become dearer to foreigners, who therefore tend to buy fewer of them.

Marshall Aid and O.E.E.C.

The Second World War (1939–45) shattered the pre-war methods of conducting foreign trade and destroyed the economic organization by which trade had been done. After the war the Allied Powers had the task of rebuilding the economic life of Western Germany and of the occupied countries. The U.S.A. gave very extensively to the work, through Marshall Aid and the Organization for European Economic Co-operation (O.E.E.C.). Gradually it became possible for most of the governments to relinquish much of their rigid, detailed control of imports and exports, and to abandon much of the bulk buying of essential commodities. Importers and exporters, little by little, regained their liberty to trade. But complete freedom in foreign trade had by no means been restored by 1955 in spite of various international conferences to consider how government restrictions, quotas, exchange controls could be avoided.

European Payments Union

In order to encourage trade between the nations, the O.E.E.C. established the European Payments Union, a type of international clearing-house, to keep and publish monthly accounts of the member-countries' imports from, and exports to, one another, and to hold a stock of gold out of which payments could be made to creditor countries. Thus, during the month of January 1955 the U.K. had a net deficit of £7·3 millions, and had a total deficit to the other countries of £122·6 millions, principally because the U.K. permitted imports much more freely than the other countries. Some of these, particularly Western Germany, still drastically restricted the import of consumer goods, although doing everything possible to expand its own exports.

Without a contrivance such as the E.P.U. it would have been impossible to continue the importation of goods from Western Germany while that country refused to permit goods to be sent in payment. E.P.U. provided systematically for payment—partly in gold, partly in goods—to be temporarily deferred, and thus gave a much needed fillip to trade. This trade was conducted in the normal way between merchants in the exporting and importing countries, and with the usual shipping documents and bills of exchange, handled by banks in the customary manner ; but details of each transaction had to be furnished to the central bank of each country (in Britain, the Bank of England). The central banks could thus prepare a statement of the total value of all imports and all exports to each country month by month and send the information to the Secretariat of the E.P.U., to be incorporated in the monthly account of members' debits and credits.

International trade consists essentially of the exchange of exports for imports ; but from about 1925 governments repeatedly attempted to set this principle at nought. They established import quotas, restricting the amounts of goods that could be sent in payment; they "blocked" currency, that is, refused to allow their nationals to pay, and thus forced their suppliers to give extended credit ; they imposed tariffs designed to make imports of certain goods so dear that nobody would buy them ; they fixed the exchange value of their currency at different rates for different kinds of trade in order to encourage certain imports or exports and to discourage others. Some countries arranged barter contracts at special rates of exchange (such contracts were a feature of the Nazi pre-1939 trade policy).

Freeing the Exchanges

Numerous international conferences were held with the object of restoring the automatic self-adjustment of international trade through the rate of exchange, as was the rule before the First World War (1914–18). At the Bretton Woods Conference, held in July 1944, an International Monetary Fund and Bank was established to make loans available to countries in order to help them to return to normal international trading habits. The subscribing countries agreed to rates of exchange fixed in relation to gold. Some progress had been made towards the rebuilding of international trade ; but international relations were still bedevilled by the legacy of indebtedness resulting from the Second World War and by the understandable desire of each nation to do what was possible so to organize its economy that it could survive should war again scourge mankind.

LESSON 30

Britain's Vital Need to Export

To the U.S.A. exporting is not really essential to enable its population to live. The territory includes such varieties of climate and has such a rich store of mineral wealth that Americans could, if really necessary, contrive to supply all their vital needs. The same is true of the Russians, the Chinese, and the Indians.

Not so with Britain, which lies wholly within the temperate zone and is densely populated. Britain's coal reserves become increasingly inaccessible ; there are no rich deposits of metals ; assets include only scenery of a distinctive beauty, a legacy of many centuries of history and the buildings and institutions that have been part of it, the British way of life and cultural links with the English-speaking world, and the intelligence, skill, and industry of the people.

In order to live Britain must import most of its cereals, meat, fat, and fruit, most of its metals, oil, and other minerals, woodpulp, and most of its textile fibres. In trying to import these things Britain has to pay prices relatively much higher than before, because so many other countries have established manufacturing industries (instead of buying from Britain), and compete in world markets for materials. Indeed, some countries, such as India, which were formerly Britain's main markets, compete with finished goods in what were formerly the other main British export markets.

Change in Terms of Trade

The terms of trade (the ratio of the prices of imports to the prices of exports) have turned against Britain ; each £ worth of exports now buys for her much less than it did of the raw materials she needs. To make matters worse, her means of payment have been curtailed through two world wars. Her income from overseas investments formerly paid for about a third of her imports ; now it buys only about a twentieth. U.K. ships now carry a smaller proportion of the world's cargoes.

What can be done ? First, Britain must economise imported material. Instead of exporting mass-produced goods embodying much material and comparatively little skill, such as unbleached cotton cloth, she must try to find markets for goods that include in their price a high proportion for processing and skill ; for example, printed finished cotton goods, wool clothes, textile machinery, instruments for controlling the working of textile machinery, motor cars, bicycles, watches, pharmaceutical products, jewelry, books, gramophone records, television sets. Instead of relying on the bulk purchase of cheap goods by Africa, Asia, and South America, Britain must now seek her customers overseas from among those who want to buy machinery to equip their own industries or can afford articles of good workmanship for their comfort or leisure. British exporters must contrive what has been well described as " complementary trade," supplying in markets overseas the types and qualities of merchandise that are not manufactured locally ; e.g. small cars in U.S.A. To do this is extremely difficult. It entails market research to discover unsatisfied needs and special preferences. But British manufacturers have shown great ingenuity and have achieved a large measure of success. The Board of Trade, the Department of Overseas Trade, and the Export Credit Guarantee Department have materially assisted.

Invisible Exports

Besides goods, the U.K. exports services, particularly transport by sea and air, banking, insurance, and such professional services as those of the accountant and the consulting engineer. The role of the latter is doubly important ; for often it is associated with the supply, installation, and maintenance of costly electrical equipment, and tends to provide a permanent link with Britain.

One form of export may appear at first a little odd : exporting by means of services rendered to overseas visitors while in Britain. An American tourist in the U.K. spends money that has the same effect on our international trading account as a sale of goods to the U.S. The attractions of Great Britain for the foreign visitor are strong, and tourism has become a principal industry. The net income from it and from the growing body of overseas students, whose expenditure also ranks as an export, may eventually exceed the interest and dividends derived from British overseas investments. Besides contributing by their expenditure to the supply of foreign exchange, overseas visitors, particularly when attending industrial exhibitions such as the British Industries Fair, are an important source of overseas orders. Some engineering companies encourage Commonwealth student-apprentices as a means of developing a permanent preference for British equipment.

In spite of all that has been done, the " trade gap " remains a continuing threat to the standard of life. From 20 per cent. to as much as 40 per cent. of Britain's total imports from year to year has to be paid for by her " invisible " exports—earnings from overseas investment, transport, banking, insurance, professional services, and tourism. Imports could be curtailed in order to reduce the "gap"; but it would mean either a smaller consumption of many things that have become semi-necessaries of life, such as fruit or tobacco, or a restriction of the capacity to manufacture goods for export. Wisely, Britain has concentrated on increasing both the visible and the invisible exports. As the market for one type of goods has withered, her manufacturers have been able to cultivate a new market for a fresh product, thanks to the ingenuity of British chemists, physicists, biologists, and engineers. Great Britain owed her material greatness during the 19th century to the lead that had been gained in textiles, shipbuilding, railways, and heavy engineering. That lead is now a thing of the past.

The country managed to emerge from the tremendous difficulties of the past few years mainly through developments in newer industries: motor cars, aircraft, artificial fibres, plastics, electronics, and pharmaceuticals. Its future depends on the ability of the designers and production engineers to make full use of the fruits of research, discovery, and invention, and to adapt these to the special circumstances of individual overseas markets.

LESSON 31

Inflation and Deflation

IN previous Lessons prices have been considered in relation to value. It is necessary also to discuss the wider implications of changes in the level of prices. A condition in which prices generally are rising, that is, the purchasing power of money is falling, is called inflation; the reverse is deflation.

Inflation will ensue when the total amount of money that people want to spend increases more rapidly than the total goods available to buy. It can be remedied by lessening their desire to spend the money (e.g. by a successful National Savings campaign or by imposing a tax on the goods), by lessening the money at their disposal (e.g. by higher income tax), or by increasing the supply of goods. Prolonged and rapid inflation can destroy a nation's trust in their money, ruin large sections of the community, and bring business to a standstill.

Main Functions of Money

Money has two principal functions: to provide a medium of exchange and to define rights and duties. If it is working efficiently as a medium of exchange, money "cancels out." Barter is the act of exchanging goods or services for other goods or services. Money splits the total transaction of barter into two parts: selling, the exchange of goods for money; buying, the exchange of money for goods. It permits any desired degree of variety to be introduced into the buying; thus, one sale of working hours during a week can be exchanged for the hundreds of things that we need to purchase. It also allows us to defer as long as we like any part of the complete barter transaction, e.g. the use of part of the wages received this week may be postponed for years, if we so wish.

Money acts also as a measure for the comparison of the values of different things, so that when one receives £1 one thinks of it primarily as a claim to certain goods. If it is functioning properly, money is a link connecting our estimate of the value of the things we give with our estimates of the value that we shall receive. But if prices change, the complete process of barter becomes distorted, as through a magnifying glass. The holder of money receives less value than he had expected if prices have risen, more if they have fallen.

Most legal contracts state certain rights or duties in terms of money; for example, wages or salary in a contract of service, rent in a lease. When entering into a contract each party undertakes a duty and receives a right; if either of these is expressed in money and the purchasing power of that money changes during the term of the contract, a variation has been unfairly introduced into the contract, which becomes less favourable to one of the parties. For example, if A takes out a 20-year endowment policy for £500 with an assurance company and during the 20-year period prices rise 100 per cent. he will at the end of the period receive only half the right to the goods and services of the community that he had expected. Changes in the price-level strike at the heart of everyday contracts, and may leave one of the parties totally dissatisfied.

Effect of Rising Prices

Rising prices benefit debtors and all others who have to make payments, at the expense of creditors and all those having the right to be paid money. Such changes can easily convert what seemed to be a generous rate of interest into what Professor Fisher, a famous American economist, called "negative interest." Thus, if £100 is lent at 5 per cent. per annum for 3 years, and during that time prices rise 20 per cent., the £115 received when the loan is repaid will have a purchasing power equal only to that of $\frac{5}{6}$ of £115, or £95 5s. 6d. of the £100 lent; the lender would actually have lost over 4 per cent. of his purchasing power. At various times economists, and occasionally business men, have proposed the use of an index number as a correcting factor to avoid distortion in long-term contracts. For example, if that had been done in the illustration just given, the lender of the £100 would have been repaid £120 for his principal, plus $\frac{6}{5}$ of £15, i.e. £18, as interest. An approach to the use of such an index number is to be found in the agreements of trade unions and employers' federations to link rates of wages with the Retail Price Index, so that as the purchasing power of money falls, more of it is paid and vice versa. Some millions of workers enjoy the protection that such "sliding scales" afford.

Prices are the indicators that business men follow. Rising prices promise bigger profits. They induce optimism, and encourage business men to take risks. Trade therefore tends to be "good" during a time of rising prices. The converse is true. But the greater prosperity during rising prices is partly illusory; for business men in their bookkeeping do not usually make allowance for the higher price they will have to pay to replace the things they use. The wear and tear of machinery, for example, continues to be reckoned as a percentage of the old cost instead of the new cost; often materials consumed in manufacture are brought into account at the old price and not at the cost of getting new supplies. Indeed, a firm's accounts during a period of rapidly rising prices may show a handsome profit, yet in reality the business may finish the period worse off than it began in equipment, stocks, and cash.

To keep prices stable is a primary duty of those in charge of a country's affairs; but it is a duty that few governments fully discharge. Some economists have argued that as rising prices benefit debtors and as they are on balance the more active members of the community, the ideal condition is one of continuous slight inflation, to provide an additional stimulus to business activity and risk-taking. In no country yet, however, has there been sufficient economic stability for this theory to be tested. Prices have zig-zagged upward, with here and there a steep fall that has paralysed commercial activity, and here and there a leap upward that has brought misery to the wage earners.

LESSON 32

Taxation and its Economic Effects

TAXES are among the most ancient of social institutions. From the earliest days rulers have taxed their subjects. Originally taxes were payable in kind—so many days of labour or so much wheat, wool, or other typical product; but as the use of money developed, taxes payable in kind tended to be commuted to money payments. The practical effect is the same. The medieval villein had to work for the lord of the manor so many days a week; the modern citizen has to work to pay his taxes, though nowadays he almost certainly derives more benefit from the services of the state than did his medieval forebears. In Great Britain the taxes and local taxes (or rates) now amount to between a third and a half of the total national income.

Reasons for Levying Taxes

Taxes are levied, in the first place, to pay for the cost of government, the maintenance of law and order, and the provision nationally of essential services that it would not be possible for all individuals to provide for themselves. The second purpose is to pay for national defence. This becomes increasingly costly. The major part of all government expenditure in most countries is in connexion with the avoidance of war, or preparations against war, or the claims arising out of the expenditure of past wars. The third reason is to re-distribute part of the national income, so that none may be below what is considered to be a minimum subsistence level.

The basis of the latter idea can be found in the ancient charitable care for the aged and infirm; during the 20th century it has gradually widened (in the U.K.) into a comprehensive system of social security, comprising the National Health Service, Sickness and Unemployment Pay, Retirement and Old Age Pensions, and Public Assistance. The fourth reason is to finance national development, particularly the development of people through pre-natal and maternity services, educational facilities (nursery schools, primary, secondary, and technical schools and colleges, universities and other institutions of further education), the development of industries through scientific and industrial research, and the development of natural resources through afforestation, hydro-electric works, coast conservation, land drainage, etc.

For all these purposes the government has to spend vast sums of money, and when levying taxes to provide them has to contrive that the taxes shall produce much revenue. Speaking generally, such taxation tends to increase the total amount available for spending on consumers' goods and can stimulate trade and industry, though it can reduce the amount that is being saved for investment in producers' goods.

Some taxes are really most successful when they produce no revenue at all. That is so when the tax is imposed as a deterrent. A famous

British statesman, David Lloyd George (1863-1945), as chancellor of the exchequer avowedly increased the tax on beer and spirits to discourage their consumption. Purchase tax was introduced during the Second World War to lessen the effective demand for unrationed goods. Where taxes are imposed on customary necessaries, such as cigarettes and tobacco, they amount to a penalty or fine enforced against certain types of habit—in the 1950s, for example, the cigarette smoker paid about 2s. 9d. "fine" by way of tax included in the price of a packet of 20 cigarettes.

"Protectionist" Taxes

The so-called "protectionist" taxes are those levied on certain kinds of imported goods in order to discourage their importation and hence to encourage the use of home-produced goods. A perfect protectionist tax yields no revenue at all. It makes the imported variety of goods relatively so dear that it is priced right out of the market and nobody will buy it. But most protectionist taxes go only part of the way. They give the home producer some protection against foreign competition, but not a monopoly of supply. By doing this they can shelter relative inefficiency in production, and impair a country's full exploitation of its natural economic aptitudes. On the other hand, by preventing full specialisation and fostering diversification of industries they lessen a country's dependence on overseas markets and the political policies of other countries. Most countries try to safeguard certain of their industries by protective import duties.

Commonwealth Preference

Some import duties are designed to distinguish among goods according to their foreign origin. For many years the U.K. has taxed various kinds of goods at a lower rate if they come from one of the countries of the Commonwealth, thus giving them what has been called an Imperial (later, Commonwealth) Preference. Most of the countries of the Commonwealth have given a similar preference to goods imported from the U.K. This practice has been strongly criticised by some other countries, particularly the U.S.A.

Incidence of Taxation

All taxes are really levied on people, although for convenience they are often expressed in relation to things. For example, a tax on tobacco is a tax on smokers. Some person has always to bear the brunt of a tax, and he may not be the one who pays the money to the tax collector. For example, purchase tax is paid to the Excise Department by the wholesaler; but it is understood that the person who buys the article from the retailer will bear the burden of the tax. Where the burden of the tax falls is called its incidence. It is often most difficult to determine this; for example, who really bears the petrol tax? A direct tax is levied directly on a person, who may be unable to pass on the burden, or "shift" the tax; for example, stamp duty of 2d. on receipts of £2 or more—a tax on receivers of money; licences (dog, gun, motor, etc.), partly taxing people because of their habits, partly registering their habit in case of accidents. Indirect taxes are related to commodities, and the individual who will pay the tax—the subsequent buyer of the commodity—is usually not identifiable at the time the tax is paid; e.g. purchase tax, and import duty on wine.

Adam Smith's Four Rules

As long ago as 1776 Adam Smith, in his *Wealth of Nations*, stated four rules of taxation which are still accepted as essentials of a good fiscal system:

(a) *Equality of Sacrifice:* taxing according to the ability to pay, i.e. according to the revenue enjoyed. Taxes on semi-necessaries, poll taxes such as dog-licences, and most stamp duties, are from this point of view bad taxes.

(b) *Certainty:* each individual should be able to calculate what is due from him, and when and how it has to be paid. The tax collector should be allowed the minimum of discretion.

(c) *Convenience:* the tax should be levied at the time and in the manner least inconvenient to the contributor. For example, taxes on income, levied at the time it is received (P.A.Y.E.); taxes on imports, when the goods are imported; taxes on amusements, as part of the cost of the ticket.

(d) *Economy:* the tax should be simple to collect, and should not impede production or raise prices by more than the amount of the tax. Income tax and most stamp duties conform with this principle; most Excise duties do not.

Assessment of Taxes

Taxes are normally assessed on revenue or income, and on expenditure or consumption. Most stamp duties, however, are levied on transactions; for example, a payment by cheque is taxed 2d., a receipt for £2 or more is taxed 2d. Most taxes on consumption and on transactions violate Adam Smith's first rule: they are not graded according to the ability to pay.

Generally, capital is not taxed. A person owning a house worth £4,000 will not be taxed on the £4,000 capital, but on the estimated value of the annual use of the house, that is the rent it would fetch. An important exception is the type of tax known as Death Duties; these are assessed on the capital receivable by the heirs of a deceased person, a secondary purpose of the tax being to break up large aggregations of capital and the economic power that goes with them.

The local taxes called District Rates are still assessed on the assumption that the annual value of a person's house corresponds to his income and his ability to pay. While this assumption was broadly true at the beginning of the 20th century, there is little to justify it now; and many people have advocated a local income tax to finance local services.

No consideration of taxation would be complete without mention of one form of tax that is wholly pernicious, and most damaging to the economic welfare of any people—taxation through the issue of additional paper money to meet mounting government expenditure. In medieval times it was taxation through the debasement of the coinage, by the issue of smaller coins or coins containing less gold. Modern governments have the easier way of issuing notes, and this method of taxation has caused intense misery in many countries of Europe. It is never far distant when governments do not balance their annual budgets.

LESSON 33

The Maintenance of Employment

EMPLOYMENT has a triple significance: it is the means through which the income of the community is created; it is the principal source through which individuals gain their right to share in the income of the community; it is the chief instrument through which the individual's status among his fellows is fixed.

Importance of Employment

A society is very sick where many people are for long periods unemployed. Not only is there a great waste of productive potential, so that the total income is less than it might have been, but the unemployed and their families lack the necessaries of life, and deteriorate; they feel they are excluded from the community, which has no use for them. Areas of mass unemployment become derelict areas in every way.

The effects of unemployment are so serious for a nation and for the unemployed that to maintain employment should be, next to national defence, the first concern of any government. Fortunately the lessons of the terrible mass unemployment of the years between the First and the Second World Wars have been learned thoroughly, and to-day much more is known about the causes of unemployment and the remedies for it than was appreciated then.

To consider the problem it will be necessary to analyse the productive process. People are employed for one of two purposes: (a) to render a personal service, as in a household, or (b) to co-operate in the production and selling of either a personal service, e.g. hairdressing, laundry or a material commodity. Material commodities fall into four classes: consumers' perishable goods, intended to be used up quickly, e.g. articles of food or household supplies; consumers' durable goods, used up over a period of years, e.g. dwelling-houses, furniture, motor cars; producers' perishable goods, such as materials and stores, e.g. lubricating oil, steel bars; producers' durable goods, e.g. buildings, machinery. The same thing can sometimes be either a producers' good or a consumers' good, according to the purpose for which it was used; e.g. petrol consumed in the family car for a Sunday ride is a consumers' good; that used in a builder's lorry when carting equipment is a producers' good.

The proportion in which people are employed to produce these four types of commodity tends to be determined by the employer's estimate of the profit that he will make. This in turn is the difference between his expected price and his expected total cost. The larger this expected profit margin, the stronger is the tendency to increase the volume of production. The force governing employment is therefore merely an expectation. This may be based on most careful analysis of thousands of facts, or may be just a guess. If it is wrong, the entrepreneur will try to stop the production as quickly as possible, and if he can he will divert it into other channels promising more profit. The maintenance of employment must at all times, therefore, depend upon relatively accurate forecasting or the ability to avoid the effects of bad forecasts.

Demand and Supply Forecasts

The forecaster has to estimate demand and supply. The supply expresses the sum of the forecasts of all the producers of goods that will serve the same purpose. Individual producers plan with little knowledge of what competitors are doing in regard to either existing lines or new developments. Technological change is so rapid that it is exceedingly difficult for producers of durable goods to estimate what will be the total supply five years hence in their own field; e.g. television sets, electrical domestic appliances, materials handling equipment, electronic calculators. There is always the possibility that a new discovery or invention will make their buildings, machinery, or methods obsolete.

The demand for personal services and for consumers' goods depends on two factors: first, the quantity of purchasing power people have and its distribution among them; secondly, their attitude towards individual services and goods. The more money we have, the smaller is the proportion that must be spent on the primary needs of food, shelter, etc., and the larger the proportion available for luxury and for saving. Thus £5 million equally distributed among 100,000 people would cause a pattern of demand very different from that which would ensue if the same sum were so distributed that 90,000 had only £10 each, 9,000 had £100 each, and the remaining 1,000 had £3,200 each. Hire-purchase facilities increase the amount of current purchasing power available for luxuries and consumers' durable goods, though tending to lessen the amount of the subsequent purchasing power for those purposes.

Changes in Taste

People's attitude towards individual goods can change profoundly and quickly—fashion is by no means confined to clothes. Advertising can do much to maintain preferences, but it does not always succeed in restoring demand once it has been lost. A change of fashion is difficult to predict. It is a risk that producers always face, and hence is always a possible cause of localised unemployment until productive resources can be diverted.

Changes in Purchasing Power

The strength of the demand for producers' machines and materials depends principally upon the purchasing power of the prospective user and his estimate of the profit that he will be able to make through the use of the machine or the material. Thus, farmers' demand for tractors will be increased if it seems likely that crops will sell at high prices or if tractors can be supplied on hire-purchase. The manufacturer of producers' goods may have to forecast years ahead, trying to assess what will be the attitude and the circumstances of his prospective customer when the goods are offered for sale. His success will really depend on his ability to forecast his own customer's estimate of the demand for his product.

The maintenance of employment therefore rests partly on faith that things will turn out as expected months or years before. This faith is easily shaken. A sudden fall in prices—even in the prices of shares on the Stock Exchange, a sudden lessening of purchasing power through the withdrawal of hire-purchase facilities, special taxation, or a bad harvest, the prohibition by a foreign government of importation of certain goods, rumours of war: any of these things can cause business men to hesitate to commit themselves, and unemployment may result.

Over-investment in specialised plant may prevent manufacturers from adapting their production to changes in demand or other altered circumstances, such as new materials or new methods. The distribution of purchasing power may be such that the power to buy consumers' goods cannot keep pace with the power to produce them. This was a principal cause of unemployment between the two world wars. Too large a proportion of the national income was saved and invested in producers' goods to manufacture things that people, particularly primary producers overseas, could not buy. The remedy for over-investment in producers' goods is higher wages, especially for primary producers, and a partial redistribution of the national income through taxation and increased government expenditure.

Whatever the purpose for which the government spends the money taken in taxes—armaments, housing, land drainage, increased defence forces, improved educational or medical facilities—the money paid in wages increases the demand for both consumers' and producers' goods.

Direct Effect of Government Spending

Because government expenditure of any kind has this effect, it can be used as a shock absorber to prevent fluctuations in employment, government expenditure being increased when trade is bad and restricted when it is booming. Such expenditure has always an effect something like that of a stone thrown into a stream—it causes widely dispersed ripples in various directions, and may permanently change the direction of flow.

Thus, an extensive re-housing programme increases not only the demand for the services of all grades of building workers, but also the demand for materials, appliances and installations, builders' equipment (ladders, concrete mixers, etc.); this in turn will affect the engineering trades, the iron and steel industry, etc., in each of which a large part of the total expenditure will be paid as wages to stimulate the demand for consumers' goods. An economic multiplier operates, so that the eventual increase in the total purchasing power of employees may be two or three times the initial expenditure.

Indirect Effect of Government Action

Besides stimulating demand directly by expenditure on public works, etc., the government can assist in maintaining employment in other ways. The whole British economy is so dependent on exports that any action which stimulates demand from overseas lessens the precariousness of the position. Manufacturers' ability to export turns partly on their prices: anything the government can do to encourage greater efficiency in production by better education and training, by disseminating knowledge of new techniques, discoveries, and inventions, helps manufacturers to reduce prices. A vast amount of research of great value to industry is now undertaken or co-ordinated by the Department of Scientific and Industrial Research and other government agencies. The British Productivity Council, which arose out of the Anglo-American Council on Productivity formed in 1948, aims at fostering an interest in better methods.

The prosperity of industry being based on good forecasting, the government can help forecasting by collecting and publishing information on which forecasts can be based. This is done extensively through the Censuses of Population, Production, and Distribution, and through the publication of voluminous official statistics. These are usually planned and supervised by advisory committees on which business and industry are represented, so that their needs can be explored and met as far as possible.

LESSON 34

Monopoly in Modern Industry

ALTHOUGH one still hears and reads often enough the phrase "the present competitive capitalist system," that system is in fact neither completely capitalist nor uniformly competitive. Not a year goes by but the sphere of state and municipal enterprise is widely extended. At the same time, and probably as speedily and to a correspondingly great degree, the field of unrestricted, cut-throat laissez-faire competition is being restricted and reduced. Although in the nature of things it is impossible to say with any exactitude how far the movement has gone and just how fast it is operating, it is undoubtedly true that in most of the big industries there has been established some form of working arrangement whereby prices are kept higher than they would be if every business concern was playing its own hand. In Britain as elsewhere these arrangements take many shapes and forms.

Large-Scale Enterprise

Always the cutting out of " wasteful competition " is at their root, but the drive to monopoly is only an aspect of the movement towards the establishment of larger and larger business units. Specialisation can be carried to much further lengths by the big firm than by the small—specialisation in machinery and labour power, in the processes, and in locality of production. Raw materials of any and every kind may usually be purchased on more advantageous terms since they are being bought in bulk. More advantageous rates may be obtained from transport concerns ; capital may be raised more cheaply, and temporary loans arranged on easier terms. Extensive advertising schemes may be launched ; large sums may be spared for market and technical research. Wasteful duplication may be cut out, particularly in distribution.

If a firm or group of firms has the happy feeling of knowing that a very large proportion of the consumers of its particular " line " *must* come to it to satisfy their requirements, then it can considerably reduce its costs.

The fear that the supply of raw materials may dry up at a critical moment, or that their prices may be raised unduly, is banished when (as often happens) a firm establishes a vertical trust, embracing every stage from the source of raw material to the supplying of the consumer. The other fear which oppresses business men, that a competitor may cut prices and steal the market, is laid when all or a preponderance of the firms potentially competitive are brought under the same management or ownership. An element of monopoly is something which industrialists and business men are constantly striving to secure, while the consumer of their products is just as anxious to see that the monopolistic element shall be kept as small as possible.

In a broad sense, a trust is any big business concern, or amalgamation or association of such concerns, which enjoys some considerable measure of monopoly in its particular field. The word is derived from a form of business organization which came into prominence in the U.S.A. in the 1880s; to secure the advantages accruing from a monopolistic position a number of business enterprises agreed to assign the whole of their respective stocks (what in Britain are usually called shares) to a small board of trustees who managed the concerns as if they were one large, non-competing unit. The associated firms received by way of exchange trust certificates representing the agreed value that was put on their properties. But this was only the beginning of a great variety of monopolistic combinations, all of which are frequently described as trusts even though the " trust " element does not enter into to-day's picture.

Principal Forms of Trust

Nowadays the trust movement is exemplified in three principal forms, as follows :

(a) The *amalgamation* of all, or nearly all, the most important firms in a particular field of business ; in this case the previously competing firms cease to exist.

(b) The *association* of leading firms of an industry in a kind of alliance, for certain specified purposes, particularly the maintenance of an agreed price-list and the sharing-out of the territory of the " market," while the firms still retain their individuality so far as the public are concerned and for purposes other than those included in the terms of the pact.

(c) The establishment of a *holding company*, a new firm which is permitted to buy a controlling interest in a number of firms which, it has been agreed by those responsible for their direction, shall no longer compete with one another but secure as far as possible the profits of monopoly.

Whatever the form adopted, it is not necessary that to dominate an industry the whole of it shall come into the hands of one giant trust ; in other words, the monopoly need not be absolutely complete and watertight. Indeed, it seldom is ; usually there are some firms which prefer to stand on their own feet, in the hope and belief that they will be able to give the customer more of the *exact thing* that he wants, as opposed to the trust's ability to supply mass-produced articles. An industry may be dominated, however, just as effectively by two, three, four, or half-a-dozen monster firms as by one ; and in America the economists talk of duopoly, triopoly, and oligopoly as being the business units in an economic system of " imperfect competition."

Even when an industry has become a monopoly or, say, a triopoly, it may still be exposed to competition—the *competition of substitutes*. To take an easy if somewhat fantastic example, if an electricity board increases charges to what the consumers regard as unfair levels, the latter will " switch over " to gas ; if the gas and electricity boards are working hand in glove, then there is still paraffin—or candles.

American Attempts at Limitation

In the U.S.A. laws have been passed from time to time aiming at the suppression of monopolistic combinations which are held to be opposed to the public interest. In 1890 the Sherman Anti-Trust Act made it an offence to " establish or attempt to establish a monopoly." This Act and others like it were insufficient, however, to do more than hamper a powerful business trend ; and for generations the " company lawyers " have fought a not unsuccessful battle with the government and the supreme court. But it is still illegal in the U.S.A. for a company to acquire shares in another company if by so doing there is a " real diminution of the competition between companies " or if it " tends to establish a monopoly." And price discrimination between different purchasers, aiming at the lessening of competition or the creation of a monopoly, and the granting of discounts or rebates on condition that the buyer shall not deal with the grantor's competitors, are also condemned.

In Britain there is a long-established Common Law rule that restraints on trade are bad, and contracts or agreements in restraint of trade are unenforceable in the courts. Industrial combinations are not usually regarded as being in restraint of trade, however, whatever they are in fact. Public opinion has always been against the " stop-list," that is, circulation to the members of a trade association an instruction to withhold supplies from a named trader because he has infringed one of the association's practices, e.g. sold goods at less than standard prices.

British Efforts at Control

In 1948 the Monopolies and Restrictive Practices Act was passed, and it was strengthened in 1953. This Act established a Monopolies and Restrictive Practices Commission, to which the President of the Board of Trade can refer for investigation and report either monopoly and restrictive practices in specified industries or similar practices in industry generally. The reports are usually published, and generally receive wide notice in the Press and in Parliament. If the reports reveal practices against the public interest, appropriate steps may be taken, including legislation if necessary, to stop them. The Commission reported on a great number of subjects, including the supply of dental goods, electric lamps, insulated electric wires and cables, insulin, matches and match-making machinery.

The British method is not to legislate to forbid trusts but rather through such means as the Monopolies and Restrictive Practices Commission and other publicity to control them. Only when these methods fail is legislation resorted to. Indeed, the establishment of the British Broadcasting Corporation, the National Coal Board, British Railways, the Gas Boards, the Central Electricity Authority, etc., were all examples of the statutory creation of monopolies because the government of the day considered that such controlled monopoly would conduce to the public good.

Advantages of Monopoly

The advantages of efficient large-scale organization, when appropriate and when suitably organized and managed, are so great that it would be foolish to assume that monopoly is necessarily undesirable—as foolish as to assume that it is everywhere beneficial. It is generally recognized that it must be watched and controlled, where necessary ; the difficulty is in watching it and in assessing its efficiency and advantages. Trustification in privately owned undertakings has proceeded in Britain principally through the holding company, the individual units retaining their separate identity and trading under their own names (with or without a slight modification).

An important aspect of monopoly is the oldest—the patent. The grant of monopoly by letters patent has been part of the royal prerogative in most countries, and has taken centuries in Britain to bring under parliamentary control. The purpose of patents is to benefit the community by encouragement of the use of inventions and discoveries. The inventor is given by the grant of a patent the sole right to make, use, and sell an invention for a limited period of time. Vast sums have been invested by companies in the purchase and development of patents. It is almost impossible to judge whether, on balance, individual patents operate in the public interest or whether patents generally do so, in spite of the legislation that has been passed to ensure that they shall. Many of the tightest links between companies are forged by the common use of patents. The social value of trade marks and designs is clear: they protect both the manufacturer and the buyer of the article.

The real dangers latent in monopoly are not so much those associated with a slight increase in price for a household necessary, though that can be serious enough when the commodity is in universal daily use. Quite often the economies of large-scale production enable the combine to produce the thing much more cheaply than would otherwise be possible, and to offer it at much less than the true monopoly price. The real dangers are aesthetic and political. The monopolised undertaking can control, by mass advertising, our taste and our habits. The aggregation of capital concentrates in the hands of a few people immense political power. They may use it with a due sense of social responsibility, or they may not.

LESSON 35

The Economist in Commerce and Industry

SUCCESS in commerce and industry depends partly on ability to foresee demand and supply. But it becomes increasingly difficult to read the signs of the times. A board of directors, when considering whether it shall manufacture and market a new type of electronic apparatus, for instance, has to think in terms of two, three, or more years ahead, and have regard not only to what is happening in Britain, but what industrialists are doing in America, Germany, Japan. The task is immensely difficult. The majority of business men rely on the professional economist, who may be a full-time member of the staff or a consultant in market research

Tasks of the Professional Economist

The professional economist is the modern astrologer. He has to " look into the seeds of time, and say which grain will grow and which will not." He reads not the stars but statistics. He will, for example, have to assess the trend, i.e. the direction and the degree of the movement of prices of materials, so that a company may know when it would be best to buy what it needs, and whether it would pay to try to substitute material A for material B. He has to interpret the effect now, six months hence, and a year or more ahead, of developments at home and abroad. He has to estimate how much could be sold of products X, Y, Z, at various prices in different places. He has to advise whether or not it would pay to build a new factory in Britain, in Canada, or elsewhere.

Practically any problem for future activity may be referred to him for examination, from the economic—that is, the quantitative and £ s. d.—angle. The board of directors of a furniture manufacturing company may want to know what is the probable supply of dining-room suites in London, Birmingham, Manchester, and Glasgow ; a manufacturer of ventilating appliances may seek guidance on the desirability of substituting, say, copper or aluminium for lead or steel ; a company manufacturing electronic apparatus for testing the quality and weight of packeted food may need information concerning possible sales throughout the whole world. Any board of directors can be helped by all the information it can be given concerning its competitors, its customers, its suppliers, wherever they may be.

The services that the economist may be asked to give to his company or, if he is a consultant, to his client, are therefore most varied. Equally diverse are the sources of his information. They include English and overseas daily newspapers, the technical and trade periodicals, journals of learned societies and trade associations, government reports and statistics, and so on. He has to be sufficiently aware of the implications of the statements they contain to be able to separate the wheat from the chaff. He must be able to appreciate the kinds of thing that he should tell those whom he serves. The service he can thus render can be of extreme value not only to his company but also to the community as a whole.

Occasionally the economist providing these services is entitled Economic Adviser ; more often he will be known by some other name, such as Personal Assistant to the Managing Director, Market Research Assistant, Information Officer, Intelligence Officer, or even Economic and Financial Research. In a large undertaking he will have assistants to help him with the routine work, and may, indeed, be the head of a department. Thus, in one company producing by the hundreds of million a commodity used in many kinds of manufacture throughout the world is an economist, known as the Manager of Information and Intelligence, who has a staff of about a hundred men and women. His department receives and sifts facts gathered from an immense variety of sources at home and abroad, and distils from them a service of economic information for each of the departmental managers. On the basis of this information there is prepared a detailed forecast of the selling and manufacturing activity of the whole undertaking, including its factories overseas. The Information and Intelligence Department in this case has become the eyes and ears of the organization.

A small business has the same need as the large undertaking for economic information ; but in most cases the head of the small business has to collect it himself, though he can be much helped by information furnished by trade associations, research organizations, and the trade and financial press, who employ trained economists. A rather more specialised type of economic research has to be undertaken by the economists employed by stockbrokers, insurance companies, banks, employers' federations, and trade unions. In some departments of the Civil Service highly qualified economists are employed to investigate proposals and to advise on alternative policies. And on almost every national newspaper is at least one fully trained economist.

The professional economist should have had a university training with special emphasis on economics, economic geography, commercial, industrial, and social organization, and statistical method. He should be able to read French and German, and should have good mathematical ability and skill.

BOOK LIST

General. *The Social Framework*, J. R. Hicks (O.U.P.) ; *The Acquisitive Society*, R. H. Tawney (Bell) ; *Leadership in a Free Society*, T. N. Whitehead (O.U.P.) ; *Full Employment in a Free Society*, Lord Beveridge (Allen and Unwin) ; *Wealth and Life*, J. A. Hobson (Macmillan).

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ENGLISH LANGUAGE

FOLLOWING a lesson on the essentials of grammar which are common to most languages, ancient and modern, comes our Course on English. In this the student will read of the origins and history of English, and of those particular rules of grammar which apply to it, thus learning to make the right use of his own tongue in speech and writing.

Courses which are complementary to this on the English Language are those on ENGLISH LITERATURE *in Vol. 2, and on* PHILOLOGY *and* PHONETICS *in Vol. 5. The student who wishes to pursue his study of languages further will find Courses on* LATIN *and* FRENCH *(Vol. 2),* GERMAN *and* GREEK *(Vol. 3),* ITALIAN *and* SPANISH *(Vol. 4),* RUSSIAN *and* PORTUGUESE *(Vol. 5).*

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First Things to Know About Grammar

THIS Lesson is introductory to the whole series of language Courses. It contains, in summarised form, information concerning parts of speech, inflexion, conjugation, number and gender, case, comparison, and so on, which should be mastered before the student turns to any of the Courses dealing with specific languages—Latin, Greek, French, German, Italian, Spanish, Portuguese, and Russian, as well as English.

Language is the expression of thought by means of words. A word is a combination of elementary sounds, to which a certain meaning is attached. The meaning of the word is what is thought of when the word is used, though this may be governed by other words used with it.

Words are generally used in groups called sentences. A sentence is an expression of a complete thought, as when one says "We know" or "To be or not to be; that is the question."

The rules for changing the form of words to express differences in meaning, and for grouping words in sentences, are called Grammar. English grammar and all other grammars are those portions of the general science of language which treat of the spoken or written language of the English, French, German, and other peoples.

The grammar of any language falls naturally into two parts. The first is that which deals with separate words; the second is that which deals with words combined to form sentences. The first part treats of the variation of form which words undergo to mark changes in their relation to other words, and of the manner in which they are formed out of simpler elements. The name given to this is *accidence*, because it shows what changes may befall words—Latin *accidere*, to befall.

The second main division of grammar, dealing with words combined in sentences, is called *syntax*, from the Greek *syntaxis*, arrangement. The rules of syntax are statements of the ways in which the words of a sentence are related to each other. Syntax deals both with the order of words in a sentence and with the particular inflexions that are required in any given sentence to express the desired meaning.

The classes in which words may be arranged are called *parts of speech*. These are the same in most of the European languages. The English names for the eight parts of speech—all derived from their Latin equivalents—are as follows:

1. A Noun (*nomen*=name) is a word used as the name of something—e.g. bird, *avis* (Latin), *oiseau* (French); James, Jacques.
2. An Adjective (*adjectivus*=that is added to) is a word used with a noun to describe, to measure, to count, or to indicate that for which the noun stands—e.g. *hot* days, *four* boys, *this* man.
3. A Pronoun (*pro*=instead of) is a word used instead of, or to avoid repeating, a noun—e.g. "When Elizabeth died, *she* was seventy years old."
4. A Verb (*verbum*=word) is a word by means of which something is stated—e.g. "Birds *sing*."
5. An Adverb (*ad verbum*=to a word) is a word which shows how an action, state, or quality is modified or limited—e.g. "He speaks *eloquently*."
6. A Preposition (*prae-positus*=placed before) is a word which shows how things, or their actions and attributes, are related to other things—e.g. "The Mill *on* the Floss"; "Come *unto* Me." It is usually placed before the noun which it governs.
7. A Conjunction (*con-junctio*=joining together) is a word which joins together words or sentences—e.g. "Man proposes, *but* God disposes"; "Come, buy wine *and* milk."
8. An Interjection (*inter-jectus*=thrown between) is a word thrown in to express some feeling or emotion. It has no grammatical relation to the sentence in which it stands—e.g. "Alas!"; "Hurrah!"

Inflexion

Inflexion (Latin, *inflectere*, to bend) is a change made in the form of a word to denote a modification of meaning, or to show the relationship of the word to some other word in the sentence.

Nouns, pronouns, and adjectives are inflected to mark number, gender, and case. This is called declension. In Latin there were five methods of declension, in Greek three, in German the strong and the weak declensions, etc. The old grammarians used to speak of the subject (or nominative case) as the "upright" case and of all the other cases as "oblique."

Case

The word "case" means "a falling," and the oblique cases were conceived of as falling away or "declining" from the nominative. Hence the declension of a noun is a statement of its cases—i.e. of the forms which it assumes in various relations. The full number of cases is seven, but the actual number in use varies in different languages.

Nominative (including the Nominative of Address, sometimes called the Vocative)—e.g. "*He* is going out." "*The man* is well known." "*John*, come here!"

Accusative (the case of the direct object)—e.g. "The man saw *the dog*; he saw *me*."

Dative (the case of the indirect object)—e.g. "I give *him* a book."

Genitive (the case denoting origin or possession)—e.g. the *horse's* head.

Ablative (the case denoting separation from).

Locative (the case denoting place at which).

Instrumental (case denoting association with).

The last two became merged in the ablative in Latin. In English the last three case-relations and that of the dative (except for pronouns) are expressed by phrases with prepositions—e.g.

"It comes *from London.*" "He killed him *with a dagger*," etc.

Gender

The distinction between male and female in nature is called sex. The distinction between masculine and feminine in words is called Gender. The English language adopts the natural distinctions of gender: names of animals of the male sex are masculine, names of animals of the female sex are feminine, names applied to animals of either sex are common, and names of things of neither sex are neuter. Other languages, such as Latin, French, and German, often distinguish gender by noun endings, irrespective of meaning; thus, in German, *Mädchen*=a little maid, is neuter: and in French, *la table*=the table, is feminine.

Number

Number is the difference in words to express one or more than one—singular or plural. Some languages have special forms to denote two persons or things; this is called the dual.

Comparison

Adjectives and adverbs are inflected to mark degree. This inflexion is called Comparison. There are three degrees of Comparison—Positive, Comparative, Superlative. A positive adjective compares a thing with all other things, and ascribes to it a certain quality—e.g. *long*, *beau* (French), *altus* (Latin). A comparative adjective compares the thing named with one other, and shows that the former has more of a certain quality than the second—e.g. *longer*, *plus beau*, *altior*. A superlative adjective compares the thing named with several others—at least two—and shows that it possesses a certain quality in a higher degree than any of the others —e.g. *longest*, *le plus beau*, *altissimus*. The same applies to adverbs.

Conjugation

Verbs are inflected to mark voice, mood, tense, number, and person. This inflexion is called Conjugation. Voice is the form of the verb by which it is shown whether the subject of the sentence stands for the doer or for the sufferer of the action spoken of by the verb. Most languages have two voices—Active (where the subject of the sentence is the doer of the action, e.g. I *strike*) and Passive (where the subject of the sentence "suffers," or is the object of the action, e.g. I *am struck*). Greek has a middle or reflexive voice in addition.

Mood is that variation of the verb used to express the mode or manner of an action or of a state of being, e.g. simple statement (Indicative mood), command (Imperative), possibility (Subjunctive). When a verb has no subject expressed or implied, it is said to be in the Infinitive mood; the other moods are finite.

Tense indicates the time to which an action or event is referred; in all languages the natural division is into past, present, and future, with different varieties and shades of meanings of each.

Person is a modification of the form of a verb by which it is shown whether the speaker speaks of himself (first person), or of the person or persons addressed (second person), or of some other person or thing (third person).

To conjugate a verb is to give all its tenses and moods, and the full conjugation of a verb is the formation of all the inflexions and combinations used to indicate voice, mood, tense, number, and person. The four conjugations in Latin or French are the four modes of forming the tenses in those languages. In English there are two "conjugations," strong and weak; the former modifies the vowel-sound of the root to form the past tense (*write*, *wrote*); the latter adds *-ed* or *t* to the stem (*love*, *lov-ed*). Prepositions, conjunctions, and interjections are not inflected.

Analytic and Synthetic Languages

A language which is rich in inflexions, like Latin or Greek, is called *Synthetic* (Greek, *synthetikos*=able to put together), because it puts many meanings and relations into one word. A language which has simplified its inflexions, like English or French, and uses separate words instead, is called *Analytic* (Greek, *analytikos*= able to split up or take to pieces: *cf.* the noun analysis).

The tendency of languages is to pass from synthetic to analytic, and the languages which are to-day analytic were originally far more synthetic, if not entirely so. This tendency is notable in the passage from Latin to French, and in that from Old English to Modern English. Old English, for example, was an inflexional or synthetic language: its nouns had four cases, and there were different declensions: adjectives were declined, and had three genders; pronouns had more forms than they have to-day, and some had a dual number, as well as a singular and plural; the verbs had more variety in the terminations. Gradually, in the three centuries following the Norman Conquest, most of these inflexions were dropped, and separate words (such as prepositions and auxiliary verbs) were used in their stead. For example, the old English word hām (=home) was declined thus:

Case	*Singular*	*Plural*
Nominative	hām	hāmas
Accusative	,,	,,
Genitive	hāmes	hāma
Dative	hāme	hāmum

There is no short cut to the acquisition of a language, that is, to the thorough understanding of it. Of course, a language can be very easily picked up by a short residence among the people who speak it. But merely to repeat certain sounds is not to know a language, even if the sounds are pronounced quite correctly. To know a language one must understand the why and the wherefore of all the inflexions of its words and their relationship one with another in any sentence of that language.

Begin with the Sentence

Therefore the best way to study a language and to learn its grammar is to begin with sentences, not with single words. The unit of speech is the sentence, and the exact meaning of a word cannot be determined until it is seen in a sentence. It is thus a mistake to start learning the grammar of a language by committing to memory pages of rules and paradigms, or by confining oneself to acquiring a large vocabulary of its words.

It is with the sentence that the pupil should begin his study. Once a sufficient number of sentences has been assimilated it will be easy to analyse them into their component parts, and to show the relations that these bear to one another. As Professor Sayce says :

> In this way the learner will be prevented from regarding grammar as a piece of dead mechanism or a Chinese puzzle, of which the parts must be fitted together in accordance with certain artificial rules, and will realize that it is a living organism which has a history and a reason of its own. The method of nature and science alike is analytic ; and if we would learn a foreign language properly we must learn it as we did our mother-tongue, by first mastering the expression of a complete thought, and then breaking up this expression into its several elements.

ENGLISH LANGUAGE

LESSON 1

Outline History of the Language

THE history of the English language is the history of the English people. As one traces the growth of the nation, one also traces the growth of the language. Words are fossilised history. They speak of waves of conquest, of eras of strife, of the gradual victory of the arts of peace over the arts of war ; they tell of the hopes and fears, the expectations and disappointments, the laws, customs, dress, and manners of those who dwelt in England long centuries ago.

Up to about the year A.D. 450 the British Isles were inhabited by different Celtic races, speaking various dialects of the Celtic group of languages. These races were closely allied to the inhabitants of Gaul (as France was then called), and spoke virtually the same tongue. About the beginning of the Christian era both Britain and Gaul were conquered and overrun by the Romans, but with strikingly different results as far as language was concerned. The conquered Gauls adopted the Latin language, but on the Celts of Britain that language made singularly little impression. To a great extent they retained their own dialects. However, the Latin language was destined to have its revenge ; for the Franks and Normans, who subsequently occupied France, adopted the language of that country, and were instrumental in introducing it (in an altered form, of course) into Britain about the time of the Norman Conquest.

Celtic Words

Among the earliest elements in our language, therefore, are the old Celtic words, that have survived in the struggle for existence through two thousand years and more. These are not many, for the language of the Britons was almost completely displaced by that of their Saxon conquerors.

The Celtic words consist chiefly of geographical names—e.g. *Devon*, *Dorset*, *Kent*, *Exe* ; *Avon*, *Ouse*, and *Usk* (all three meaning water), *Trent*, *Dee*, *Don*, *Severn*, *Wight*, *Bute*, *Pen* (as in *Penrith*). Also, as one would expect, words dealing with household matters, names of implements used by serfs, etc.—e.g. *ass*, *brock* (a badger), *druid*, *down* (a hill), *cross* (noun) ; and indirectly (through the Norman-French) words like *basket*, *bran*, *gown*. One of the Celtic dialects is still spoken in Wales. The Romans left singularly few words as the result of their occupation.

Coming of the Anglo-Saxons

Not long after the departure of the Romans from Britain, fresh conquerors descended on its defenceless shores. From about A.D. 450 to 550 a constant succession of Jutes, Saxons, and Angles streamed over from the lowland region in north-west Germany. Conquering the Celtic inhabitants, they drove them steadily northward and westward into the lowlands of Scotland, and into Cumberland, Westmorland, Wales, and Cornwall. These tribes were of Germanic stock. As their area of conquest extended, their language naturally prevailed more and more, until in course of time (long before the Norman Conquest) it was spoken from the Firth of Forth to the English Channel. This language, which became gradually broken up into a number of dialects, is known as Old English ; and it is the direct ancestor of the English of to-day.

The introduction of Christianity brought into the language many Latin words with an ecclesiastical connotation—mostly the names of church dignitaries, ceremonies, and the like. They came either directly from the Latin, or indirectly through Latin from the Greek. Examples of the latter are *bishop, presbyter, baptism, eucharist, monk, clergy.*

Scandinavian Elements

Meanwhile during all these centuries the Norsemen and Danes were constantly landing in more or less successful attempts at conquest. These were Scandinavian peoples, whose language was of the same group as English (Germanic). Many of their words remain in the language. A number of place-names in the north and east of England are Scandinavian—e.g. Grimsby, Whitby (*by*=town) ; Furness, Skegness (*ness*=headland) ; Troutbeck, Welbeck (*beck*=brook) ; Orkney (*ey*=island) ; Aira Force, Scale Force (*force*=waterfall) ; Thorpe, Grimsthorpe (*thorp*=village) ; Dingwall, Thingwall (*thing* or *ding*=place of meeting) ; Langwith (*with*=wood) ; Lowestoft (*toft* =small field).

The Norman Conquest

The Normans introduced their language (a descendant of Latin) when they introduced themselves. This is the third, and perhaps the most important, invasion by the Latin tongue. Norman-French became the language of the upper classes and of the law courts : even to-day the Sovereign uses this language when she gives her assent to, or withholds her assent from, bills that have passed the two Houses of Parliament. For a time the mass of the English people clung tenaciously to their old language, but gradually the two peoples began to blend, and English assumed the form which it has to-day—a fusion of Old English and Norman-French. Nevertheless the basis of the language, including the commonest words and all the grammar, remains thoroughly English.

The majority of the words in the language which relate to feudal institutions, to war, law, and the chase were introduced in this way, and, to quote but one example, to this day the town crier perpetuates the Norman-French word " Oyez " (the imperative of *oyer*, to hear) in his " Oh yes ! Oh yes ! Oh yes ! "

Influence of the Renaissance

The Renaissance, the great revival of the study of the classical languages that took place in the 16th century, gave an immense number of Latin words to the language. This is the fourth, and virtually the last, invasion on the part of Latin. A craze arose for using long, cumbersome, and unwieldy words taken straight from Latin, and even from Greek. The authors of this period and school often make painful reading. In their works can be found, for example, the following uncouth creations : torve and tetric=*stern, severe* ; cecity=*blindness* ; insulse=*tasteless* ; facinorous=*guilty*.

Many of the words thus introduced have long since perished, and during the last hundred years or so there has been a reaction in favour of a return to a purer English diction.

Quite often the same Latin word has given two words in English, one direct from the Latin, the other through the medium of Norman-French. For example :

Latin	*Direct from Latin*	*Through Norman-French*
Fragilis	fragile	frail
Ratio (-nem)	rational	reason
Potio (-nem)	potion	poison
Quietus	quiet	coy
Punctum	punctuate, etc.	point
Factum	fact	feat

Borrowed Words

In later times English has borrowed words from almost every language under the sun. Some of the chief of these sources are :

Chinese. Caddy, junk, gong, nankeen, tea.

Turkish. Bey, ottoman, sash, tulip.

Persian. Bazaar, attar, sherbet, turban, chess, dervish, hookah, lilac, musk, taffeta.

Hebrew. Sabbath, seraph, cherub, amen, leviathan, jubilee, Satan, ephod.

Arabic. Alchemy, alcohol, algebra, almanac, alembic, tariff, zenith, zero, nadir, talisman, naphtha, coffee, mosque, fakir, giraffe, harem, sultan, vizier.

Hindustani. Muslin, calico, rupee, lac, pundit, sepoy, thug, suttee, chutney, jungle, pariah, nabob, bungalow, coolie, curry.

French. Etiquette, soirée, menu, eau-de-vie, chef, ennui, bouquet, bon-bon, trousseau, carte-de-visite, tête-á-tête.

Spanish. Alligator, armada, matador, toreador, battledore, galleon, cargo, bolero, eldorado, tornado, renegade, verandah, castanets, chocolate, don, negro, mulatto, grandee, pillion.

Italian. Banditti, macaroni, folio, quarto, stiletto, stucco, incognito, gazette, brigand, gondola, influenza, motto, opera, concert, and nearly all the terms used in music.

Dutch. Boom, schooner, sloop, skipper, yacht, reef, skate.

Gaelic. Clan, tartan, pibroch, slogan, plaid.

Portuguese. Caste, cocoa, palaver, porcelain, marmalade, commodore, fetish.

Polynesian. Taboo, tattoo, boomerang, kangaroo, wombat.

American Indian. Squaw, wigwam, pampas, papoose, tobacco, tomahawk, maize, pemmican, potato, hammock.

Scientific words used in botany, medicine, etc., mostly come from Latin or Greek.

The Five Periods of English

It is possible to trace five distinct periods or stages through which the English language has passed.

1. OLD ENGLISH. This period extends roughly up to the time of the Norman Conquest, at the close of the 11th century. There were four main dialects of the language—*Northumbrian* and *Mercian* (the two together sometimes called *Anglian*) in the North, and *West Saxon*

and *Kentish* in the South. The S.E. Midland variety of the Anglian branch, which included the dialect of London, became the parent of modern standard English.

2. EARLY MIDDLE ENGLISH. This lasted from about A.D. 1100 to A.D. 1250. The most noticeable feature is the influence of Norman-French on spelling and vocabulary. During this period many of the inflexional endings became confused and often vanished.

3. MIDDLE ENGLISH. This lasted from about A.D. 1250 to A.D. 1350. The weakening influence of Norman-French was still more pronounced, and the language became rapidly analytic. The English of these first three periods is very different from that of to-day, and needs to be studied almost as though it were a foreign tongue.

4. LATE MIDDLE ENGLISH. This period (A.D. 1350–1450), of which Chaucer is the shining light, sees the language approaching much nearer to the modern form. A great deal of Chaucer can be read at once by any person of average education. It was during this period that the London dialect became predominant.

5. MODERN ENGLISH. 1450 to the present day. During this period many changes in sound took place. These were not followed up by corresponding changes in the spelling, because the early printers adhered to the conventional spelling of the 14th century.

Germanic v. Romance

These two elements have blended together to form modern English. But the basis, or framework, is Germanic. It is true that there are more than twice as many classical or Romance words in the language as Germanic, the respective numbers given by some authorities being 29,000 and 13,000. Yet the majority of those used belong to pure English stock, and when we want to express our finest feelings, or to interpret the deepest things of life, we naturally resort to that language. As a rule, the Germanic words are the shorter. Most words of three or more syllables, and many of those of two, are classical ; while in most words of one syllable, and very many of two, the Germanic element prevails. It is at once the simpler and the more dignified. A wise writer will avail himself of both elements. He will never choose a classical word when a Germanic one will do equally well, but he will see to it that while the superstructure may be Romance, the basis of his language will be English.

Germanic Words

The following are the chief Germanic elements in the English language : pronouns, numerals, prepositions, conjunctions, adjectives of irregular comparison, auxiliary verbs, all verbs of strong conjugation and some of weak, also most words relating to house, farm, family, parts of the body, common natural objects, common actions and things, trades, etc.

On the other hand, words relating to law, religion, government, war, science, art, and philosophy are mostly classical.

One great advantage given to the English language by this blending of two distinct elements is that it is particularly rich in words of similar though not identical significance. It can therefore express delicate shades of meaning that are impossible in other languages. Notice, for example, the following list of pairs, one word being Germanic, the other classical :

Germanic	*Classical*	*Germanic*	*Classical*
cold	frigid	breadth	extent
hard	difficult	feeling	sentiment
bitterness	acerbity	life	existence
God	deity	love	passion
work	labour	worship	adoration
bloom	flower	fire	conflagration

This list might be extended to almost any length. It will be noticed that on the whole the Germanic words are more " nervous " and expressive than the classical. As a rule, they come first to one's mind, the others being used subsequently to avoid repetition or to amplify the meaning. Naturally, the finest English poetry is mainly composed of the Germanic element. Shakespeare is well worth studying from this point of view alone. The Authorised Version of the Bible, Bunyan, and Defoe contain whole paragraphs composed almost entirely of English words. For simplicity and pathos there is nothing to beat pure English. In large measure the charm of such a piece as, say, Tennyson's " Crossing the Bar " lies in the fact that it contains hardly any but Germanic words :

Sunset and evening star,
  And one clear call for me,
And may there be no moaning of the bar
  When I put out to sea.

But such a tide as moving seems asleep,
  Too full for sound and foam ;
When that which drew from out the boundless deep
  Turns again home.

Classical Style

A very good example of the classical style is to be found in the works of Walter Pater. If one opens them at any page one finds majestic, sonorous sentences, almost every other word of which is of classical origin—e.g. from *Marius the Epicurean*.

> His old native susceptibility to the spirit, the special sympathies, of places—above all, to any hieratic or religious significance they might have—was at its liveliest, as Marius, still encompassed by that peculiar singing, and still amid the evidences of a grave discretion all around him, passed into the house. That intelligent seriousness about life, the absence of which had ever seemed to remove those who lacked it into some strange species wholly alien from himself, accumulating all the lessons of his experience since those first days at Whitenights, was as it were translated here, as if in designed congruity with his favourite precepts

of the power of physical vision, into an actual picture. If the true value of souls is in proportion to what they can admire, Marius was just then an acceptable soul.

Aryan Languages

The languages of the world are arranged in families, according to original identity in grammar and vocabulary. One of these families is known as the Indo-Germanic or Aryan family. It includes :

1. *Sanskrit*, which is the classical language of India, and exhibits the Aryan grammar in its most perfect form.
2. *Persian*, the earliest literary form of which is called Zend.
3. *Balto-Slavonic*, including Russian, Polish, Czech, Serb, Lithuanian, Lettish, etc.
4. *Hellenic*, including all Greek dialects.
5. *Italic*, including Latin, together with the Romance languages derived from Latin, e.g. French, Italian, Spanish, Portuguese.
6. *Celtic*, comprising Gaelic (i.e. Irish, Manx, and Scottish Gaelic) and Cymric (i.e. Welsh, and the Armorican of Brittany).
7. *Germanic*. This group now consists of two main sections, Scandinavian and West Germanic. *Scandinavian* includes Icelandic, Swedish, Norwegian, and Danish. *West Germanic* comprises High German (the languages spoken in South Germany), Low German (the languages spoken in the northern lowlands of Germany), English, Frisian, Dutch, and Flemish.

Not all the European languages are of Indo-Germanic stock. Turkish, Finnish, and Hungarian were introduced from Central Asia in fairly modern times.

In addition to words that have been imported into English, there are many English words, or roots of words, that are common to most of the Aryan languages. These have not been borrowed one from another, but all the different languages have received them from an earlier source. In this respect the English language is a single member of a large family of related tongues.

EXERCISE

1. From what Latin words are the following doublets derived ? *Hospital* and *hotel* ; *pauper* and *poor* ; *redemption* and *ransom* ; *senior* and *sir* ; *rotund* and *round* ; *junction* and *joint*.
2. From what languages are the following words borrowed ? *maize, tattoo, cocoa, slogan, yacht, quarto, pillion, bouquet, jungle, zero, leviathan, attar, ottoman, tea-caddy*.
3. Re-write in modern English :

   Whan that Aprillè with his shourës soote
   The droghte of March hath percëd to the roote,
   And bathëd every veyne in swich licour
   Of which vertu engendred is the flour ; . . .
   Thanne longen folk to goon on pilgrimages.

   Chaucer (*Prologue to Canterbury Tales*).
4. What words of classical origin are to be found in Tennyson's " Crossing the Bar " ?

LESSON 2

The Alphabet and Spelling

The English alphabet is the Roman alphabet, with the addition of the letter w. It consists of twenty-six letters, written both as small letters and as capitals.

Capital letters are used at the beginning of proper names ; also at the beginning of every new sentence, and of every line of poetry. The pronoun I and the interjection O are always capitals. Capitals are also used when writing any appellation of the Divine Being, e.g. Thou, He, and in such expressions as Her Majesty, His Excellency, etc.

Capitals. A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z.

Small. a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, w, x, y, z.

The English alphabet is both redundant and defective : redundant, because it contains three letters (c, q, x) indicating sounds which are also indicated by other letters (c=k or s, q=k, x=ks or gs) ; defective, because there are only twenty-six letters (twenty-three virtually) to express at least thirty-four sounds. For the eleven sounds which have no special letters, certain combinations of letters are used, such as ng, ee, au, sh.

Vowels

The letters a, e, i, o, u represent sounds which are called Vowels (Lat. *vocalis*=soundable), because they can be fully sounded with no check in the passage of the breath. The remaining letters represent sounds called Consonants (" sounding with ") ; during their articulation the air-stream is wholly or partially checked. *W* and *y* may represent either a consonant or a vowel ; when they are followed by a vowel sound in the same syllable, they are consonants, as *world*, *yield*. When a vowel precedes them in the same syllable in spelling they combine with it to form either a diphthong (see below), or a simple vowel sound, as *buy*, *few*. *Y* is a pure vowel when followed by a consonant, as *Ygdrasil* ; this was its original use ; it was first used as a consonant after the Norman Conquest.

Two vowel sounds pronounced as one syllable are called a Diphthong (" double sound "). The chief diphthongs in English are listed as follows :

Diphthongs

1. *i*, as in *bind*, *find* (*cf.* the same sound in *aye*), This sound=ă+i.
2. *oi* or *oy*, as in *hoist*, *boy*, *buoy*. It = the sound of o+i.
3. *a*, as in *make*, *may*. This sound=e+i.
4. *ou* or *ow*, as in *how*, *pound*.
5. *o* as in *stone*, *know* : =o+u.

NOTE. Where two vowels are written, but only one pronounced (gauge, boat, mien), this is not a proper diphthong.

The vowel sounds in modern standard English are as follows :

SHORT VOWELS : *a* as in m*a*n ; *e* as in m*e*n, r*ea*dy ; *i* as in b*i*t ; *ó* as in n*o*t, wh*a*t ; *u* as in b*u*t, sh*o*ve ; *oo* as in p*u*ll, b*oo*k ; the unstressed vowel heard in *u*pon, brok*e*n.

LONG VOWELS : *ah* as in f*a*ther, p*a*rt ; *ē* as in b*e*, b*ea*n ; *aw* as in c*a*w, c*au*se ; *ë* as in f*ir*, w*or*d, l*ear*n ; *ōō* as in f*oo*l.

Consonants

These are classified thus :

1. STOP CONSONANTS, e.g. *b*, *d*, *k*. In the formation of these the air-stream is completely (but momentarily) checked in some part of the mouth-passage.
2. OPEN, e.g. *f*, *s*, *th*, *w*. In these the air-stream is perceptibly hindered, but not entirely stopped.
3. NASAL, e.g. *m*, *n*, *ng*. Here the air-stream is stopped in the mouth, but the air is released through the nose.
4. DIVIDED, e.g. *l*. The air-stream is stopped by the middle of the tongue (regarded lengthwise), but passes out at either side.
5. TRILL, e.g. *r*. Here the tongue or uvula vibrates rapidly (less in English than in other languages).

Consonants are also grouped according to the part of the mouth used in producing them : the point, blade, front, or back (of the tongue), represented respectively, for instance, by *t*, *s*, *y* (in *y*ou), *k* ; the lips (*m*, *b*, etc.) ; the teeth, which may be used with the point of the tongue (as in *th*), or the lower lip (as in *f*). Thus *k* is a lip stop consonant, *l* a point divided, *m* a lip nasal, *f* a lip-teeth open, and so on.

Finally, consonants are divided into two classes, according to the presence or absence of the " buzz " which accompanies the vibration of the vocal cords. Examples of consonants in the formation of which the vocal cords vibrate, and the " buzz " (technically known as *voice*) is heard, are *v*, *z*, *m*, *g* ; these are called *voiced* consonants. In the *unvoiced* sounds *f*, *s*, *k*, etc., the vocal cords do not vibrate.

There are two pairs of consonants which are very closely linked : *t*+*sh* (usually written *ch* or *tch*) and *d*+*zh* (usually written *j*, *g* (before *e*, *i*, as in gem), or *dge* (as in bri*dge*).

The sound *h* is produced by putting special stress on the ordinary air-stream as it passes out through the throat. It is called an aspirate. In many English words, *h* is written but not pronounced, e.g. in *h*our, *h*onour.

Defects in Spelling

A perfect system of spelling or writing would be *phonetic*, i.e. would indicate exactly the sounds made in speaking. For this purpose it is necessary :

1. That there should be a letter for each spoken sound ;
2. That each letter should stand for only one sound ;
3. That in writing a word, no sound should be omitted and no unpronounced letters should be added.

English spelling breaks all these rules :

1. As there are only twenty-three letters for thirty-four sounds, there are eleven sounds without corresponding letters.
2. The letter *a*, for example, represents four simple vowel sounds, as in *fall*, *far*, *fat*, *want*, and a diphthong, as in *fate* ; *e*, five sounds (*mete*, *pet*, *herd*, *clerk*, *pretty*) ; *i* represents two simple sounds (*pit*, *fir*) and one diphthongal (*bite*) ; *o* represents at least three sounds (*poke*, *pot*, *for*) ; *u* represents four (*rude*, *pull*, *fun*, *fur*). *Cf.* *his* and *this* ; *dough* and *cough*.
3. Letters are often written which are not pronounced ; these are useless as signals of the spoken word, e.g. :

c is useless in	*duck*, *scene*.
g ,, ,,	*gnat*, *reign*.
k ,, ,,	*knee*, *know*.

Syllables

A syllable consists of a single vowel or a collection of sounds pronounced together, and has only one vowel sound. Words consisting of one, two, or three syllables are called respectively monosyllables, disyllables, and trisyllables ; words of more than three syllables are called polysyllables (Gk. *polys*, many).

The division of a word into syllables should as far as possible indicate the significant parts of which the word is composed, e.g. trans-act, not tran-sact ; e-rect, not er-ect. There is, however, a limitation to this rule, for words must be divided in writing according to the way in which the elementary sounds are grouped in speaking, i.e. the division is usually made after the vowel, and the following consonant is carried on to the next syllable, e.g. hu-mour, fa-cing.

Accent is the stress of the voice upon a syllable—e.g. cátaract, pervérsion, corróde. Difference in accentuation is often the only distinction between nouns and verbs, e.g. rébel and rebél, prógress and progréss. Many words have changed their accent, and the tendency of English is to throw the accent back towards the beginning of a word. Thus Shakespeare uses *contráry*, Milton *blasphémous*, Pope *compénsated* and *effórt*, etc.

Letters and syllables lead on to words, and these, grouped according to parts of speech, will be next discussed.

KEY TO EXERCISE IN LESSON 1

1. *Hospitale* (Low Latin from *hospitem*)—*pauper*—*redemptum*—*seniorem*—*rotundum*—*junctum.*
2. See the list in page 257.
3. When April with its sweet showers has pierced the drought of March to the root and bathed every vein (of the plant) in such liquor by virtue of which the flower is engendered (brought forth)—then folk long to go on pilgrimages.
4. Clear (Lat. *clarum*), bar (Low Lat. *barra*), moving (Lat. *movēre*), sound (Lat. *sonus*), bound(less) (Low Lat. *bodina*).

LESSON 3

The Noun and its Three Cases

IN English there are eight parts of speech—noun, adjective, pronoun, verb, adverb, preposition, conjunction, and interjection. The article is sometimes regarded as a ninth part of speech, but it is more customary to include it with the adjective.

A noun is a word used as the name of something (Lat. *nomen*=name).

Classes of Nouns

There are two main classes of nouns : Proper and Common.

1. A proper noun is a name appropriated (Lat. *proprium*) to one particular thing or person, e.g. Abraham, Edinburgh.

2. A common noun is a name which all things of the same kind have in common (*communis*=shared by several). All nouns not proper are common. Examples : cat, town, coal, water.

Common nouns are subdivided into :

1. Ordinary class names, i.e. names belonging to each individual of a class, or to each portion of some material, e.g. tree, iron.

2. Collective nouns, denoting a number of persons or things forming one body, e.g. committee, jury, herd. In the plural such nouns stand for several similar collections ; e.g. the parliaments of Europe. As a rule, a collective noun has its verb in the singular ; " the government has resigned " ; but when attention is directed to the individuals composing the subject, the verb is plural, e.g. " the jury were right in finding him guilty."

3. Abstract nouns, denoting not objects, but quality, action, or state, e.g. drowsiness, walking, manhood. Also names of arts and sciences, e.g. music, biology.

Forming the Plural

In English there are only two numbers, singular and plural. A noun is said to be singular when it denotes a single object, and plural when it denotes two or more things of the same kind—e.g. book, books.

The plural is formed from the singular in several ways :

1. By far the commonest method is to add *es* (Old English *as*) to the singular : this becomes *s* when the pronunciation allows.

(a) The full syllable *es* is added only when the singular ends in a sound of *s*—i.e. *s, sh, ch* (except when it=k), *x, z,* Examples : churches, foxes, lashes (but monarchs).

(b) The letters *es* are also added after several words ending in *-o* (cargoes, potatoes, mosquitoes) ; they are not, however, sounded as a separate syllable in this or the two following cases. (A few words in *-o* simply add *s*, as solo, canto, grotto, quarto, and all in *-io* and *-oo*.)

(c) *es* is also added after *y* preceded by a consonant, the *y* being changed to *i* : body, bodies. *Qu* counts as a consonant : soliloquy, soliloquies. But if a vowel precedes the *y*, *s* alone is added, the *y* remaining unchanged—e.g. chimneys, boys, monkeys, moneys. Proper nouns ending in *y* also add *s* alone for the plural, e.g. Henrys, Ptolemys, the Berrys.

(d) *es* is also added to words of Old English origin ending in *f, fe,* and *lf,* preceded by any long vowel sound except *oo*, and the *f* is changed into *v*. Examples : life, lives ; calf, calves ; loaf, loaves. But nouns in *oof, ff, rf,* and nouns in *f* of Norman-French origin, take simple *s*, and retain the voiceless sound of the *f*—e.g. chiefs, roofs, skiffs, reefs.

NOTE : thief, thieves ; staff, staves ; wharf, wharves ; scarf, scarves.

All other nouns except those that are to be immediately mentioned add *s* to the singular—e.g. cats (voiceless *s*), dogs (voiced *s*=*z*).

2. By adding *en*, e.g. ox, oxen. *Cf.* brother, brethren ; child, children (children is a double plural, the old English plural being cild*ru*) ; eye, eyne (Spenser, Shakespeare) ; shoe, shoon ; cow, kine ; hose, hosen.

3. By changing the vowel sound of the word, e.g. man, men ; foot, feet ; mouse, mice ; tooth, teeth. To this head also belong brethren and kine, as well as to 2.

4. By leaving the singular unchanged—e.g. sheep, deer, swine. *Cf.* also : twenty brace of partridges, ten thousand horse (i.e. cavalry), ten sail of the line, a six-inch nail.

Some nouns have two plurals, differing in meaning :

brother	brothers (*by birth*)	brethren (*of a society*)
die	dies (*for stamping*)	dice (*for play*)

penny	pennies (*separate coins*)	pence (*lump sum*)
index	indexes (*of a book*)	indices (*in algebra*)
pea	peas (*separate seeds*)	pease (*collective*)
genius	geniuses (*gifted men*)	genii (*spirits, ghosts*)
cloth	cloths (*kinds of cloth*)	clothes (*garments*)

Nouns used only in the singular are names of materials or substances, and of qualities (e.g. water, gold, humour). These nouns can, of course, take a plural, denoting different sorts of the same thing—e.g. mineral waters.

Nouns used only in the plural are names of instruments or articles of dress made double (scissors, trousers); portions of the body, diseases, games, ceremonies, etc. (entrails, mumps, billiards, matins).

Alms, riches, and eaves are really singular, though often treated as plural. Amends, means, news, pains, wages are strictly plural, but are often used as singular.

In most compounds the constituent parts have so completely coalesced that there is no difficulty about forming the plural in the ordinary way—e.g. rainbow, rainbows; horse-box, horse-boxes. (Note also: spoonfuls, etc., *not* spoonsful, etc.)

But compounds of a noun and an attributive word or phrase, in which the parts have not coalesced into a single word, add the *s* to the noun—e.g. courts-martial, knights-errant, fathers-in-law. When the compound consists of two nouns imperfectly coalesced, both take the sign of the plural—e.g. lords-justices, men-servants.

Some nouns borrowed from foreign languages retain their proper plurals. Thus:

Latin

Nouns in	*a*	make	*ae* :	nebula, nebulae
"	*um*	"	*a* :	erratum, errata
"	*is*	"	*es* :	axis, axes
"	*ix* (*ex*)	"	*ices*:	vertex, vertices; appendix, appendices
"	*us* (masc.)	"	*i* :	terminus, termini
"	*us* (neut.)	"	*era* :	genus, genera
"	*ies*	"	*ies* :	series, series

Greek

Nouns in	*on*	make	*a* :	automaton, automata
"	*sis*	"	*ses* :	crisis, crises
"	*ma*	"	*mata* :	miasma, miasmata

Miscellaneous

Cherub, cherubim; seraph, seraphim; beau, beaux; madame, mesdames; bandit, banditti; virtuoso, virtuosi.

The Three Cases

Cases are the different forms which a noun or pronoun assumes to denote its relation to other words in a sentence. In modern English there are three cases—nominative, possessive, objective. The objective (except in pronouns) no longer has a different form in English; its position in the phrase or sentence shows its relation to the rest of the phrase or sentence.

The *nominative* is the case of the subject of the sentence, and denotes the person or thing about which we are speaking. It answers the question Who? or What? with the verb—e.g. *Time* flies. When the nominative names the person spoken *to*, it is called the nominative of address, or sometimes the vocative (Lat. *voco*=I call)—e.g. "*Son*, go work in my vineyard."

The *possessive* is the case by which we show that something belongs to the person or thing for which it stands—e.g. Joseph's brethren. It is the only case in nouns in which a case-suffix is now used. The possessive case in the singular, and in those forms of the plural not ending in s, is formed by adding 's to the nominative case — e.g. the boy's father; women's rights. But when the plural ends in *s*, the possessive is indicated in writing by putting the apostrophe after the s, e.g. boys' clothes, Their Highnesses' coach.

This use of the apostrophe is modern. The old possessive suffix was *es* (seen, for example, in Wednesday—i.e. Woden's day).

The apostrophe alone is sometimes used with singular nouns that end in an *s* sound—e.g. for justice' sake; for righteousness' sake. This is admissible, but we must write Jones's Dairy, St. James's Palace, not Jones' Dairy, St. James' Palace, for we do not omit the *'s* in speaking. In a complex name, the possessive suffix is attached only to the last word of the name—e.g. the Duke of Gloucester's carriage; with Mr. and Mrs. Brown's compliments.

The *objective* case is that form or relative position of a noun or (pronoun) which denotes that the noun or pronoun stands for the object of the action indicated in some verb in the active voice, or which comes after a preposition. A noun is therefore in the objective case when it is the object of a verb or is governed by a preposition. The objective case answers the question Whom? What? after the verb. In nouns the objective case is the same in form as the nominative; usually therefore, the two are distinguished by their position in the sentence, the nominative coming before the verb, and the objective after—e.g. "The Greeks (nom.) defeated the Persians (obj.)." "The queen (nom.) was in the parlour (obj. after *in*)."

The objective, besides corresponding to the Latin accusative (direct object, as above), also corresponds to the Latin dative (indirect object, *to* or *for*)—e.g. "Tell *me* your story"—where *me* is indirect and *story* direct object. "I wrote *him* a letter" (I wrote a letter to him).

Syntax of the Noun

The syntax of the noun deals with the manner in which a noun is related to the other words in a sentence.

NOMINATIVE CASE. 1. Complementary nominative. The verbs *to be*, *to become*, and passive verbs of naming, making, appointing, deeming, etc., take a nominative after them as well as before: "It is *I*." "Descartes was called the father of modern philosophy." In colloquial speech one often hears It's me, That's him, but strictly these phrases are not grammatical.

2. Nominative absolute (corresponding to ablative absolute in Latin, and genitive absolute in Greek). The nominative may be used with a participle, forming with it a clause grammatically independent of the rest of the sentence, i.e. an absolute clause—e.g. "They pressed on into the heart of the mountains, *the scenery becoming more sombre at every step*." This sentence is complete grammatically even if the words in italics are omitted.

POSSESSIVE CASE. This is rarely (though oftener than formerly) used except where the noun denotes a living thing. In such expressions as the cannon's mouth, the earth's surface, the objects are personified. Traces of the old genitive case in *-es* (which the possessive replaced) are seen in: a month's notice, a day's wages, at their wits' end.

OBJECTIVE CASE. 1. The objective usually follows the verb, but when it differs in form from the nominative, or when the subject of the sentence in which it stands has a distinctive form, it may stand before the verb, without causing any ambiguity, e.g. "He saved others; *Himself* He cannot save."

2. Verbs of making, appointing, calling, thinking, take a complementary object in addition to the direct object; as, "They elected him (direct) president" (compl. obj.).

3. The verbs *ask*, *teach*, *forgive*, *banish*, etc., sometimes take a second objective—e.g. "I ask you this," "Forgive us our trespasses," "He taught me Latin," also the somewhat archaic "We banish you our territories." These verbs can take an objective even in the passive voice: "He was denied his rights."

4. The cognate objective, or objective of kindred meaning, is used after many intransitive verbs: "I have fought the good fight." "He laughed his great laugh."

Apposition

When two or more nouns are used together, as names of the same thing, they are said to be in apposition; they are always in the same *case*: "He brought his children, two little girls" (obj.). "Mr. Smith, my cousin, came with me."

Sometimes a noun stands in apposition to a whole sentence: "They dragged her away shrieking, a *sight* to move the hardest heart."

EXERCISE

Correct the following sentences:

1. The boy stood on the burning deck,
   Whence all but he had fled.
2. Whom do men say that I am?
3. This injury has been done me by my friend,
   He whom I treated like a brother.
4. Oh, a cherubim thou wast that did preserve me.
5. Where nothing save the waves and I
   Shall hear our mutual murmurs sweep.

LESSON 4

Adjectives and Articles

An adjective is a word added to a noun to qualify it, or limit it by reference to quality, quantity, or position. There are, therefore, three main classes of adjectives: adjectives of quality, adjectives of quantity, and adjectives of position or relation. Examples of the three classes are:

1. Qualitative, or descriptive, adjectives, denoting some quality or attribute: e.g. *white*, *ugly*, *thick*, *French*, *such*.

2. Quantitative adjectives, denoting *how much* or *how many*. These include:

   (*a*) cardinal numerals: *one*, *two*, etc.;
   (*b*) indefinite numerals: *many*, *few*, *some*, *all*, *enough*, *any*, *much*, *more*, *most*, *several*, *sundry*, *certain*, *none* or *no* (=*not any*), *less*, *least*, *both*.

3. Adjectives of relation, or demonstrative adjectives. These include:

   (*a*) ordinal numerals: *first*, *second*, etc.;
   (*b*) pronominal adjectives (adjectives which are also used as pronouns): *a*, *an*, *the*, *this*, *that*, *these*, *those*, *other*, *yon*; *my*, *thy*, *his*, etc.; *which*, *what*, *whether*; *each*, *every*, *either*, *neither*.

The words hundred, thousand, and million are nouns; we can say "a hundred," though not "a twenty." One hundred men is therefore one hundred *of* men, and in Old English men was put in the genitive case.

When *many* is used with *a* or *an* to denote a number of persons or things looked at individually, it takes a singular verb: "Full many a flower is born to blush unseen" (Gray's "Elegy").

No is a form of *none*, which equals "not one." The use of *none* as an adjective is archaic: "There is none other name under heaven" (Acts).

Just as many adjectives are used as pronouns (e.g. "The *other* day," adjective; "Hate the one and love the *other*," pronoun), so also many adjectives are used as nouns: "The *merciful*"; "*All* is lost"; "*Enough* is as good as a feast"; "I will not destroy it for *twenty's* sake"; "We count by *tens*."

Adjectives are indeclinable (except *this* and *that*, which have as plurals *these* and *those*).

Comparison of Adjectives

There are three degrees of comparison: the *positive*, the *comparative*, and the *superlative*. The positive is the simple adjective, e.g. "a *bright* light." The comparative compares one thing with another, and asserts that the one possesses a certain quality in a higher degree than the other, e.g. "a *brighter* light." The superlative compares one thing with many, and asserts that it possesses a certain quality in a higher degree than any of the others, e.g. "the *brightest* light."

Certain adjectives, from their meaning, are incapable of comparison: e.g. *one*, *two*, *first*, *second*, *this*, *that*, *square*, *triangular*, *perfect*, *unique*, etc.

The comparative is formed as follows:

1. By adding *-er* to the positive (or *-r*, if the positive ends in *e* mute): e.g. *long*, *longer*; *scarce*, *scarcer*. If the positive ends in *y* preceded by a consonant, the *y* becomes *i*: *lofty*, *loftier*. If the positive ends in a single consonant preceded by a single vowel, the consonant is doubled in writing: *fit*, *fitter*.

2. By prefixing the word *more* to the positive, where the positive has more than two syllables (*alarming*, *more alarming*), and usually where the positive is disyllabic (*decent*, *more decent*). The disyllabic adjectives that form their comparatives in *-er* are those ending in *y*, *ble*, *er*, *ow*, and those that have the accent on the last syllable (*prettier*, *nobler*, *tenderer*, *narrower*, *politer*). It is very much a matter of taste in these cases; what sounds best is oftenest used. Sometimes even a monosyllabic word lends itself to a more satisfactory comparative by prefixing the word *more* than by adding *-er*: thus *more right* is preferable to *righter*.

The superlative is formed as follows:

1. By adding *-est* to the positive (or *-st*, if the positive ends in *e* mute): e.g. *longest*, *largest*.

2. By prefixing *most* to the positive: e.g. *most alarming*. The remarks on the formation of the comparative apply equally here.

Double comparatives and superlatives are found in old writers: e.g. "worser"; "The most unkindest cut of all"; "The most straitest sect"; and (in modern English) "lesser."

Not all comparisons are regular. Examples of irregular comparison are:

Positive	*Comparative*	*Superlative*
good	better	best
bad	worse	worst
little	less	least
much *or* many	more	most
old	older *or* elder	oldest *or* eldest
far	farther	farthest
(forth, *adverb*)	further	furthest
fore	former	foremost, first
nigh	nigher, nearer	nighest, nearest, next
late	later, latter	latest, last

NOTE. *Elder* is not used when two persons are definitely compared in point of age.

An adjective is said to be used attributively when it immediately precedes or follows a noun; but when the verb "to be," or some similar verb, comes between it and the noun it is said to be used predicatively. Thus: "The *wise* men of Gotham" (attributive); "The wind is *chill*" (predicative).

The Articles

A, *an*, and *the* are sometimes called articles (Latin, *articulus* = a joint), but they are really adjectives. *The* has been termed the definite article, because it points out or defines, e.g. "the head of the house." It is a weak form of the demonstrative "that."

A, *an*, have been termed indefinite articles: they are weakened forms of the numeral *one*. They show that it is *one* thing of the class which is meant, but do not specify *which*. *An* is used before words beginning with a vowel or *h* silent; *a* before words beginning with a consonant or *h* aspirated, or *u* when sounded *yu*: e.g. *an army*, *an heir*, *a cat*, *a horse*, *a unicorn* (but *an umbrella*). But *an* may stand before a word beginning with *h* aspirated when the accent is not on the first syllable of the word: *an historical parallel*, *an hypothesis*. Writers differ very much on this point.

EXERCISES

(I) Pick out all the adjectives in the following passage, classify them, and give the comparative and superlative forms; say whether used attributively or predicatively:

All the earth and air
  With thy voice is loud
As, when night is bare,
  From one lonely cloud
The moon rains out her beams, and heaven is overflowed.
Chorus hymeneal
  Or triumphant chant,
Matched with thine, would be all
  But an empty vaunt—
A thing wherein we feel there is some hidden want.

(*Shelley*, "To a Skylark.")

(II) Correct the following sentences:

1. He is the tallest man of all the rest. 2. Which of these two do you like best? 3. He wore a large and a very shabby hat. 4. The King sent for the Chancellor and Treasurer. 5. Milton is greater than any poet. 6. I can see two different flags, a white and green.

KEY TO EXERCISE IN LESSON 3

1. *He* should be *him*, as *but* is here a preposition meaning *except*. 2. *Whom* should be *Who*. 3. *He* should be *him*, to be in apposition to *friend*, which is in the objective case. 4. *Cherubim* should be *cherub*. 5. *I* should be *me* for the same reason as in the first sentence.

LESSON 5

Classification of Pronouns

A PRONOUN is exactly what its name implies, a word used for a noun: e.g. "Love took up the glass of Time, and turned *it* in his glowing hands." *It* is here used to avoid repeating "the glass of Time."

As a pronoun is a substitute for a noun, it has number, gender, and case, just as would the noun for which it stands.

Pronouns are often confused with adjectives. To test a pronoun, ask the question—does this word stand instead of a noun? If so, it is a pronoun; if not, it is something else, probably an adjective. Thus: in "give John that book," *that* does not stand for a noun, and is therefore not a pronoun; it is a demonstrative adjective. But in "give John his book and that of his brother," *that* stands for "the book," and is therefore a pronoun.

Pronouns are classified as follows: Personal, Demonstrative, Interrogative, Relative, Indefinite, Distributive.

Personal Pronouns

These are: *I, we, thou, ye* or *you, he, she, it, they*, and all their cases. *I* and *we* are personal pronouns of the first person (the person speaking); *thou, ye* and *you* of the second person (the person spoken to); *he, she, it* and *they* of the third person (the person spoken of). These pronouns are thus declined:

	FIRST PERSON		SECOND PERSON	
	Singular	*Plural*	*Singular*	*Plural*
Nom.	I	we	thou	ye, you
Obj.	me	us	thee	you
Pos.	my	our	thy	your
	or mine	*or* ours	*or* thine	*or* yours

	THIRD PERSON			
	Singular			*Plural*
	Masculine	*Feminine*	*Neuter*	*All genders*
Nom.	he	she	it	they
Obj.	him	her	it	them
Pos.	his	her	its	their
		or hers		*or* theirs

The possessive cases of these pronouns are always adjectival, and are best classed as adjectives. The forms *mine, thine, ours, yours, hers, theirs*, are used only predicatively: e.g. "the loss is ours." Sometimes, however, in poetry and stately diction *mine* and *thine* are used attributively, but only before a noun beginning with a vowel: "Give every man thine ear but few thy voice" ("Hamlet"). The forms *my, thy, our, your, her, their*, are used only attributively: "my fault."

Thou and *thee* are now rarely used, except in poetry or addressing the Divine Being, in the Society of Friends, and in North Country dialect speech. The plural *you* gradually supplanted the singular forms.

It is the Old English *hit*, the *t* being a neuter suffix (as in *what, that*). Its original possessive was *his*, and *its* (no apostrophe) is a modern form: e.g. "The iron gate . . . opened to them of his own accord" (Acts).

The following are sometimes called *reflexive* pronouns, but are really personal:

Singular	*Plural*
myself (ourself)	ourselves
thyself (yourself)	yourselves
himself, herself, itself	themselves

Also the modern form *oneself*, which has no plural; it was originally written "one's self." *Self* (which means *same*), though originally an adjective, came to be regarded as a noun; hence *myself*, etc. The form "ourself" is used by royalty.

They are called *reflexive* because they are used when the action "bends back" and affects the doer: as, "He hurt himself"; "He saved others; *Himself* He cannot save" (*himself* being here *objective*). Sometimes they have no reflexive force, but are used for emphasis: as, "God Himself is with us"; "I myself say so." Here *himself* and *myself* are in the *nominative* case.

Demonstrative Pronouns

As already explained, when used to prevent repetition of the preceding noun, *this, that*, with their plurals, *these* and *those*, are demonstrative pronouns, but when used with nouns they are demonstrative adjectives. *This* and *that* in the following sentence are pronouns: "We offer you either war or peace: this means prosperity, that destruction."

Interrogative Pronouns

These pronouns—*who, what, which*, and *whether*—are used in asking questions—either direct questions, e.g. Who is there? or indirect i.e. questions depending on a previous verb, e.g. He asked who was there. *Who, which*, and *what* are also used as relative pronouns. *Who* is thus declined:

	Singular and Plural
Nominative	Who
Objective	Whom
Possessive	Whose

Which and *what* are indeclinable. *What* is the neuter of *who* (*cf. it, that*). *Whether* means which of the two? (*who-ther*).

Who is used with reference to persons only, never to things: it is always a substantive. *Which* and *what* are used both substantivally and adjectivally—e.g. "What did you go out to see?" (substantivally); "What sneaking fellow comes yonder?" (adjectivally); "Which was the braver?" (substantivally); "Which way went the Spirit of the Lord?" (adjectivally).

Who and *what* ask quite indefinitely: *which* asks for one out of a selected class or group. *What* (interrogative) is often used in exclamations, as: "What dreadful sufferings, with what patience, he endured!" (Charles Lamb).

Whether, as an interrogative pronoun, must be carefully distinguished from the conjunction —e.g. "He asked whether you were in" (conjunction): "Whether of the twain will ye that I release unto you?" (pronoun). This usage is now obsolete.

Relative Pronouns

Almost all the pronouns relate to some previous noun, but those particularly designated relative pronouns also connect the clause which they introduce with the former part of the sentence. In the sentence just written, for example, *which* is a relative pronoun referring to *clause* (called the *antecedent*), and connecting the clause "which they introduce" with the earlier part of the sentence.

Relative pronouns, therefore, introduce clauses which are *adjectival* to some noun or pronoun in another part of the sentence, for the words "which they introduce" limit or qualify the meaning of the clause.

In any sentence containing a relative pronoun —e.g. "The man whom you saw has gone"—it is clear that but for the use of the relative the sentence must have been broken into two separate parts: "He has gone": and, "you saw him." A relative pronoun is thus really a pronoun and conjunction combined.

As a relative, *that* is always substantival, and may refer to either persons or things; it is also indeclinable. It is used for *who* or *which* only when the antecedent is incomplete and requires further definition—e.g. "All is not gold that glisters." *That* may be (1) conjunction, (2) demonstrative adjective, (3) noun, (4) relative pronoun, (5) demonstrative pronoun. In the following sentence *that* illustrates each of these parts of speech in the order named: "He said that that 'that' that the boy had written was that of a bad writer."

Both *who* and *whom* are now used only of persons, but the possessive *whose* is commonly used even of lifeless things—e.g. "We bought a bookcase whose height was four feet." Many people, however, would prefer to say or write "a bookcase of which the height," etc. *What* is used only of things, and never related to any antecedent except *that* (which is always understood and never expressed); it is therefore used in the singular only—e.g. "What all desire, must be good" = that which all desire, etc.

The ordinary relative referring to animals or things is *which*, as *who* to persons. It was formerly used of persons as well. In the English Bible it is often preceded by "the"—e.g. "In the which ye also walked." It differs from *who* in that it can be used as an adjective—e.g. "Which things have indeed a shew of wisdom" (Colossians). *Who* or *which* can always be used where *that* (relative) is used.

Who, *which*, and *what* may each be compounded with *-ever* and *-soever*, and *who* also with *-so* (whoso). The forms in *-so* and *-soever* are not often used now.

Relative and Antecedent

A relative pronoun must have an antecedent, expressed or understood. This may be a noun, a pronoun, a noun-phrase, or a noun-clause. The antecedent of *who* and *that* is sometimes understood, i.e. omitted, in earlier literature—e.g. "Who steals my purse steals trash." Here *he* is understood before *who*.

The relative agrees with its antecedent in number, gender, and person; but its *case* is determined by its own clause—e.g. "The boy, *who* knew him well," *who* is third person, singular, masculine, agreeing with antecedent *boy*; its case is determined by its own clause, and is nominative because subject to *knew*. In "Those (nom.) whom (obj.) the gods love die early," *whom* is plural, common gender, agreeing with *those*, but objective case after *love*.

NOTE. *Who*, both as relative and interrogative, presents many difficulties. All such expressions as "Who did you see?" "Who did you speak to?" "I know who you mean," should be avoided in writing, but are in common colloquial use.

Omission of the Relative

The relative is often omitted, but only when, if expressed, it would be in the objective case. This is common in colloquial English: "The book he gave me is lost"; *which* or *that* is understood.

The relative should never be omitted (a) when, if expressed, it would be in the nominative; (b) when the relative clause, instead of defining or restricting the antecedent, states some further circumstance attending the antecedent, and is continuative or ampliative rather than restrictive. The difference is illustrated in these two sentences: "He broke the pen which I lent him," and "His eldest son, whom he had lost many years before, had always been his favourite. In the former, *which* defines, limits, and restricts the meaning of *pen*; in the latter *whom* amplifies and enlarges on *his eldest son*. The *which* in the first sentence could be omitted, but *whom* in the second could not be left out.

As is often used as a relative pronoun, after "same" and "such"—e.g. "This is the same as that" ; "A noise such as I had never heard before."

Indefinite Pronouns

The Indefinite Pronouns are: *One*, *none*, *aught*, *naught*, *any*, *other*, *another*, *some*. The pronoun *one* is used either (a) adjectivally, meaning "some," "a certain," or (b) substantivally, like the French *on* and the German *man*: "One can never say what will happen."

None is used for *no* when the noun is omitted, as: ". . . those kindnesses that I have done for you. I know of none." The present tendency in writing is to make *none* invariably singular, e.g. "None was present"; "There was none"; "None of these machines works."

Aught: *naught*. These are not often used now, "anything" and "nothing" usually taking their places.

Other means "one of two." It is used as an adjective and as a pronoun; in the latter case it is declined:

	Singular	*Plural*
Nom. and Obj.	other	others
Poss.	other's	others'

"The one . . . the other" are used when only two are spoken of; "one. . . another" when more than two. Similarly, the expression "one another" is not correct when used of only two persons: it should be "each other."

Distributive Pronouns

These are: *Each*, *every*, *either*, *neither*.

Each denotes all taken separately; it can be either adjective or pronoun—e.g. "Each morning she practises singing exercises" (adjective); "The guests arrived, each in his own car" (pronoun).

Every (ever-each) is very similar to *each*. It is usually an adjective—"Every child enjoyed the circus"—though originally it stood as a pronoun by itself.

Either; *neither* = one of the two (but not both); not one of the two. "Either" and "neither" should be used only when there are two alternatives: "either of the three" is wrong. *Each*, *every*, *either*, *neither* should always be followed by a singular verb, as they are always singular—e.g. "Each man knows what suits himself."

EXERCISE

In the following passage pick out and classify all the pronouns:

There was once a dog who was crossing a bridge, carrying a bone in his mouth. Looking into the water, he saw another dog, that also had a bone in his mouth. "I should like that," he thought to himself, "better than this." So he dropped his own bone to seize the other and lost them both. Who could believe that any dog could be so foolish as he?

KEY TO EXERCISE II IN LESSON 4

(II) 1. Omit "the rest." 2. "Best" should be "the better." 3. Omit the second "a." 4. If one man fills both these offices this is correct; otherwise insert "the" before "Treasurer." 5. Insert "other" before "poet." 6. Insert "a" before "green."

LESSON 6

English Verbs: Their Moods and Tenses

A WORD which says something about a person or thing, or groups of persons or things—e.g. "time *flies*," "dogs *bark*"—was originally called Verb (Latin *verbum* = a word) because it is the most important word in a sentence. Every grammatical sentence, other than a command, must contain at least two words, the one naming a person or thing (or groups of persons or things), the other telling us with regard to the first that it does something, or is in some state, or has something done to it. The first is a noun and is called the Subject, the second is a verb and is called the Predicate.

Verbs are classified as *transitive* and *intransitive*.

A transitive verb (Latin *transire* = to go across) is a verb of action which affects an object; the action "goes across" from the doer to someone or something else. Therefore every transitive verb must have an object—e.g. "shut the door; open the window."

An intransitive (or neuter) verb cannot affect an object; it denotes a state or condition, or an action confined to the doer—e.g. "Men sleep," "The top spins."

Many transitive verbs are sometimes used intransitively—e.g. "He *burst* his chains" (trans.), and "The bubble *burst*" (intrans.); "He *cut* his finger" and "This knife *cuts* well."

Transitive verbs can be used reflexively, with the reflexive pronoun either expressed or understood—e.g. "He *wounded* himself," "Planets *move* (themselves) round the sun."

Voice

There are two Voices, *active* and *passive*. A verb is in the active voice when its subject stands for the doer of the action. A verb is in the passive voice when its subject stands for the *object* of the action. Examples: "I *brushed* the dog" (active); "The dog *was brushed* by me" (passive). Intransitive verbs have no passive voice, as they pass over no action to an object.

The passive voice is formed by prefixing to the past participle of a transitive verb the different tenses of the verb "to be"—e.g. "I shall be *praised* " ; " He was *hit* by a golf-ball." Be sure, however, that the past participle is that of a transitive verb ; if it is that of an intransitive verb, the voice is active—e.g. " He *is* dead "; " I *am* come." One could equally well say, " He *has* died " ; and " I *have* come."

Moods

When a verb makes a direct statement or asks a direct question, it is said to be in the *Indicative* Mood (Lat. *indicare* = to point out). When a verb conveys a command it is said to be in the *Imperative* Mood (Lat. *imperare* = to command). When it expresses not so much a fact as the speaker's conception of the fact, or his supposition about the fact, the verb is in the *Subjunctive* Mood. These are the three Finite moods—called " finite " because the action or state denoted by them is limited by consideration of number, person, and time.

There is the fourth Mood, the *Infinitive*, in which the notion expressed by the verb is absolutely " infinite," unlimited by number, person, or time—e.g. " I cannot *speak* for laughing " (i.e. " I am not able *to speak* ").

INDICATIVE MOOD. In the English verb there is an infinitive mood, a gerund and two participles, and three finite moods—the indicative, imperative, and subjunctive. The indicative mood is used whenever a statement is made or a question is asked about something which is regarded as a matter of fact : e.g. " London *is* burning " ; " How *are* you ? " The indicative may even be used to express condition, provided that the condition or supposition relates to some matter of fact rather than to some matter of conception ; e.g. " If he *betrays* me, he will be sorry for it." This will be more fully explained later.

IMPERATIVE MOOD. This form expresses a command, and is strictly used only in the second person : " *Come* here ; *read* this letter to me." To express a command or exhortation in connexion with the first or third person, one uses either the imperative (second pers. sing.) of *let*, followed by the infinitive (e.g. " *Let* us go to the theatre "), or the subjunctive mood of the verb in question—e.g. " God *save* the Queen."

SUBJUNCTIVE MOOD. This mood was so called because it was most often used in subordinate (subjoined) sentences. It is impossible for the subjunctive to be used in a simple direct statement or question. It is used chiefly in (1) conditional clauses, introduced by *if* (though not always, as we have seen with regard to the indicative) ; (2) purpose clauses, introduced by *in order that* or *so that*, as " Take an umbrella, so that you *don't* get wet " ; (3) wishes, as " O that he *were* here ! "

The subjunctive mood is becoming more and more rarely used in English. It is being replaced (1) by the indicative (instead of " If he *were* here, all would be well," it is becoming increasingly common to say, " If he *was* here," etc.) ; (2) by the use of some auxiliary verb, as *may*, *might*, *should*.

INFINITIVE MOOD. This is really a verbal noun. It is a noun because it can stand as the subject or the object of a verb, as " *To be* is nobler than *to have* " (subject) ; " Learn to *dance* well " (object). It is a verb because it can govern an object, as " It is a good thing to avoid overwork."

Although the infinitive is generally used with the preposition *to* before it, the *to* is not a part of the infinitive. Many verbs are followed by the infinitive without *to* ; these include the auxiliaries *do*, *shall*, *will*, the verbs *bid*, *dare*, *make*, *let*, *can*, *may*, *must*, *need*, and some verbs denoting the operation of the senses, e.g. *hear*, *see*, *feel*. Originally, the *to* was prefixed only when the infinitive was used to denote purpose, as " I have come *to mend* the window." The infinitive is sometimes used in exclamations, as " *To think* that I could have been so foolish ! "

It is wise to avoid using the *split infinitive*, i.e. the insertion of any word or words between the *to* of an infinitive mood and its verb. Most authorities would agree that " I must ask you *kindly to excuse me* " is preferable to " I must ask you *to kindly excuse* me " ; but this is really a matter of taste and euphony. A split infinitive is a solecism rather than an error, and at least is better than some of the awkward lengths to which some pedantic writers would go to avoid it.

The past infinitive (e.g. *to have seen*) needs careful handling when used after another verb in the past tense. Many people will say " I should *have liked* to *have seen* you," which is, strictly speaking, incorrect ; it should be " I should *have liked* to *see* you."

Gerunds and Participles

The gerund (Latin *gerere*=to carry on) is a verbal noun like the infinitive, and has a similar meaning. The participle is a verbal adjective (Latin *participare*=to partake, because it partakes of the nature both of verb and adjective). As these are not finite moods, they are sometimes classed as infinitive moods.

The gerund, being a verbal noun, can be used in most of the constructions of a noun. It is formed from the verb by adding *-ing*. Gerunds are often confused with abstract nouns ending in *-ing* (Old English *-ung* and *-ing*), though they are really quite distinct. It is correct to say either " By *dredging* the river " (gerund), or " By the *dredging* of the river " (noun). The rule is quite simple : when *the* precedes, *of* must follow; but if *the* is omitted, *of* must also be omitted. Thus a gerund, when formed from a transitive verb, can govern an object just like any other part of the verb. The gerund, like the infinitive, can be either the subject or the object of a verb—e.g. "*Walking* is capital exercise" (subject), "I like *walking*" (object). Although the gerund has the same meaning as the infinitive, the two are not always interchangeable; for instance, after prepositions the gerund is almost always used, as "I had no idea then of *going* abroad." The gerund can, of course, be used in the passive voice as well as in the active—as, "The joy of *being loved*."

In such archaic expressions as "I go *a-fishing*," "There came three ships *a-sailing*" (where the *a-* represents *on*) we must treat the form in -ing not as the gerund, but as a modern form of the old abstract noun.

Many compound nouns are formed from gerunds, e.g. "*skipping*-rope" (a rope for skipping). Contrast such a compound noun with others like "*humming*-bird" which does not mean "a bird for humming," but "a bird which hums." "Skipping-rope" could not be rendered "a rope which skips." This shows the difference between a gerund (skipping) and a participle (humming) or verbal adjective.

Participles, like all adjectives, refer to some noun about which they specify something. There are two participles formed by inflexion, the *Present* or *Imperfect*, and the *Past*.

The present participle is always active and always ends in *-ing* (like the gerund, with which it is often confused), e.g. "*Thinking* he had come, I opened the door." *Thinking* is a verbal adjective agreeing with *I*.

It is most important for the student to be able to differentiate between the three parts of speech ending in *-ing*: the Abstract Noun, the Gerund, and the Present Participle. To distinguish a gerund from a present participle, ask the question "Does the word in question play the part of a noun or an adjective?" If the former, it is a gerund; if the latter, a participle. Contrast "By *talking* my throat gets tired" (gerund) with "*Talking* loudly, they left the room" (participle, agreeing with *they*).

It is all too common a mistake, especially in the hurriedly written sentences of a newspaper, to use the participle where a gerund should be used. To say "I heard of *you* winning the prize" is wrong; it should be *your*, because *winning* is the gerund (i.e. a noun). *You* could only be used if *winning* were a participle—e.g. "You, *winning* the prize, are a happy man." In personal and relative pronouns, the gerund and the possessive (*my*, *thy*, *his*, etc.) should be used, not the participle and the objective—as, "I am sorry for *his* (not *him*) lapsing into bad ways"; "They told me of *his* (not *him*) running away."

Thus there are three totally different classes of words in *-ing*. (1) The abstract noun, as "The *courting* of danger is foolish." (2) The gerund, as, "He perished in *courting* danger." (3) The participle, as, "The foolish fellow, *courting* danger, met his death."

The past or passive participle ends in *-d*, *-ed*, *-t*, or *-en*: "*Refreshed* by our night's rest, we resumed our journey next morning."

The past participle can be compounded with the verb "to have" to form an active verb, and with the verb "to be" to form a passive verb. The Old English past participle usually had *ge-* (pronounced *yĕ*) prefixed to the verb: traces of this remain in the archaic words: *yclept* (called), *yclad* (clothed), *yslaked* (slaked).

Participles often come to be used as mere adjectives—e.g. "a *frowning* hill," "a *broken* reed."

The following compound participles are used in English: (*a*) the past participle compounded with "having," to form a perfect participle active, as, "*Having spoken* these words, he died"; (*b*) the past participle compounded with "being," to form an imperfect participle passive, as "*being warned*"; also the same compounded with "having been," to form a perfect participle passive, as, "*having been warned*"; (*c*) a loose kind of future participle, as "*About to die*, we salute you"; "*about to be killed*."

CORRECT THE FOLLOWING SENTENCES:

1. I had wanted to have seen him.
2. Trusting you are well, believe me yours truly.
3. In the reading the Psalms, the clerk made many mistakes.
4. Had he have gone he would have regretted it.

Tenses

The different forms assumed by a verb to indicate time are called Tenses (Latin *tempus* = time). There are three natural divisions of time—Past, Present, Future; and corresponding to these are three main tenses in Grammar. But an action in each of these three tenses can be looked at from three distinct points of view—as Incomplete, as Complete, as Indefinite. This gives nine Primary Tenses, as follows:

	INCOMPLETE	COMPLETE	INDEFINITE
	(1)	(2)	(3)
PAST *Act.*	I was loving	I had loved	I loved
" *Pass.*	I was being loved	I had been loved	I was loved
	(4)	(5)	(6)
PRES. *Act.*	I am loving	I have loved	I love
" *Pass.*	I am being loved	I have been loved	I am loved
	(7)	(8)	(9)
FUT. *Act.*	I shall be loving	I shall have loved	I shall love
" *Pass.*	I shall be being loved	I shall have been loved	I shall be loved

In addition to these nine Primary Tenses there are three Secondary Tenses, called Perfect Continuous (in the active voice only):

1. I have been loving.
2. I had been loving.
3. I shall have been loving.

Nearly all the tenses are formed by using auxiliary verbs, *be*, *have*, etc. Such tenses are called Compound Tenses, as opposed to Simple Tenses, i.e. those which contain only a single word (*I love*, *I loved*). An alternative form of the past and present indefinite is " I *did* love," " I *do* love." Sometimes the *do* and the *did* are used for emphasis, as " I *did* think you would have come earlier." *Do* and *did*, however, are used in questions and in the negative, as " *do* men say ? " rather than " say men ? " " I *do* not like you " rather than " I like you not."

PAST TENSE. The simple past tense (past indefinite) is used in three ways : (1) it points out, without any qualification, that something occurred in the past, as : " William of Normandy *conquered* England in 1066 " ; (2) it is used with the meaning of an imperfect tense : " As they *sat* by the stream they watched the birds " (=*were sitting*) ; (3) it expresses what happened frequently or customarily : " In those days men *travelled* well-armed " (=*used to travel*).

PRESENT TENSE. The simple present tense (present indefinite) is used in the following senses : (1) it states what is actually taking place, as " The rain pours down the windows " ; (2) it denotes what regularly takes place, as : " Each morning the postman comes " ; (3) it often stands for the future, especially after *when*, *as soon as*, etc., e.g. " As soon as I *hear*, I will let you know " ; " When he *comes*, I will ask him what to do " ; (4) it is sometimes—chiefly in rather archaic verse—used in describing past events, the speaker adopting the present tense in order to be more graphic.

FUTURE TENSE. The future tense is formed with the auxiliary verbs shall or will. Thus, I shall come, thou wilt come, he will come, we shall come, you will come, they will come. In the second and third persons, the verb " shall " denotes obligation or authority, e.g. " you shall not go " ; " He shall not enter this house again." On the other hand, in the first person, " will " implies determination, e.g. " I *will* do it, though the heavens fall." An often-quoted sentence illustrating the wrong use of these auxiliary verbs is that of the man struggling in the water : " I *will* be drowned, and nobody *shall* save me." It is alleged that Scotsmen are especially prone to this confusion.

SEQUENCE OF TENSES. Generally, if the verb in the principal clause is past, the verb in the dependent clause will be past likewise ; if it is present or future, then the verb in the dependent clause will be present or future.

LESSON 7

Conjugation of Verbs

IN English, verbs, like nouns, have two numbers, singular and plural. The latter is without inflexion in all verbs save " to be." Verbs are inflected, however, for person. There are three persons, first, second, and third —the person(s) speaking, spoken to, and spoken of.

The two principal auxiliary verbs are : " To Be " and " To Have."

Conjugation of Verb TO BE

INFINITIVE MOOD

Present	*Past*
to be	to have been

PARTICIPLES

being	been, having been

GERUNDS

Simple	*Compound*
being	having been

INDICATIVE MOOD

	Past	*Present*	*Future*
Indefinite	I was	I am	I shall be
Complete	I had been	I have been	I shall have been

SUBJUNCTIVE MOOD

	Past	*Present*
Indefinite	I were, or might be	I be, or may be
Complete	I had been, or might have been	I have been, or may have been

NOTE.—A third form of the subjunctive past tense is formed with *should* instead of *might* ; I should be ; I should have been.

IMPERATIVE MOOD

Singular	*Plural*
Be (thou)	Be (ye)

The full conjugation of the Present Indefinite Indicative is : I am, thou art, he is, we are, you are, they are ; and of the Past : I was, thou wast, or wert, he was, we were, you were, they were.

In the compound tenses there is no inflexion, except of the auxiliary verbs " have," " shall," etc., to be given later.

All tenses of *to be* can be used as auxiliaries to form compound tenses of other verbs (e.g. " I shall have been writing ").

Conjugation of Verb TO HAVE

INFINITIVE MOOD

Present	*Past*
to have	to have had

PARTICIPLES

having	had, having had

GERUNDS

Simple	*Compound*
having	having had

INDICATIVE MOOD

Past	Present	Future
	Indefinite	
I had	I have	I shall have
	Incomplete	
I was having	I am having	I shall be having
	Complete	
I had had	I have had	I shall have had
	Perfect Continuous	
I had been having	I have been having	I shall have been having

SUBJUNCTIVE MOOD

Past	*Indefinite Present*
I had I might have I should have	I have I may have
Incomplete	
I were having I might be having I should be having	I be having I may be having
Complete	
I had had I might have had I should have had	I have had I may have had
Perfect Continuous	
I had been having I might (or should) have been having	I have been having I may have been having

IMPERATIVE MOOD

Singular	*Plural*
Have (thou)	Have (ye)

The full conjugation of the Present Indefinite Indicative is: I have, thou hast, he has, we have, you have, they have; and of the Past: I had, thou hadst, he had, we had, you had, they had.

Only the Indefinite tenses of *to have* can be used as auxiliaries for the purpose of forming compound tenses of other verbs.

COMPLETE CONJUGATION OF THE VERB "TO SEE"

The forms marked with an asterisk are seldom, if ever, used in modern speech. It will be seen that many forms in the Subjunctive of the Active Voice are the same as in the Indicative.

(A) Active Voice. INFINITIVE MOOD

Present Indefinite : (To) see
Present Incomplete : (To) be seeing
Perfect : (To) have seen
Continuous Perfect : (To) have been seeing

PARTICIPLES

Present : Seeing *Perfect :* Having seen
Continuous Perfect : Having been seeing

INDICATIVE MOOD

Past	*Present*	*Future*
	Indefinite	
I saw (*or*, did see)	I see (*or*, do see)	I shall see
	Incomplete	
I was seeing	I am seeing	I shall be seeing
	Perfect	
I had seen	I have seen	I shall have seen
	Continuous Perfect	
I had been seeing	I have been seeing	I shall have been seeing

Imperative Mood

Singular : See (thou) *Plural :* See (ye)

SUBJUNCTIVE MOOD

Past	*Present*
	Indefinite
I saw I might see I should see	I see I may see
	Incomplete
I were seeing I might be seeing I should be seeing	*I be seeing I may be seeing
	Perfect
I had seen I might have seen I should have seen	I have seen I may have seen
	Continuous Perfect
I had been seeing I might have been seeing I should have been seeing	I have been seeing I may have been seeing

(B) **Passive Voice.** INFINITIVE MOOD

Indefinite	*Perfect*
To be seen	To have been seen

Passive Voice (*cont.*)

PARTICIPLES

Indefinite : Being seen
Perfect : Seen, *or* having been seen

INDICATIVE MOOD

Past	*Present*	*Future*
	Indefinite	
I was seen	I am seen	I shall be seen
	Incomplete	
I was being seen	I am being seen	*I shall be being seen
	Perfect	
I had been seen	I have been seen	I shall have been seen

(No Continuous Perfect in the Passive.)

IMPERATIVE MOOD

Singular : Be (thou) seen
Plural : Be (ye) seen

SUBJUNCTIVE MOOD

Past	*Present*
	Indefinite
I were seen I might be seen I should be seen	*I be seen I may be seen
	Incomplete
*I were being seen *I might be being seen *I should be being seen	*I be being seen *I may be being seen
	Perfect
I had been seen I might have been seen I should have been seen	I have been seen I may have been seen

The four simple tenses of the Active Voice are now given in full :

INDICATIVE MOOD

Past Indefinite		*Present Indefinite*	
I saw	we saw	I see	we see
thou sawest	you saw	thou seest	you see
he saw	they saw	he sees	they see

SUBJUNCTIVE MOOD

Past Indefinite	*Present Indefinite*	
(Same as Indicative)	I see	we see
	thou see	you see
	he see	they see

In page 271 in tabular form is the conjugation of an ordinary verb (other than an auxiliary) in its various voices, moods, and tenses. The alternative forms for the indicative indefinite (*did see*, *do see*, etc.) are used only in negative, interrogative, and emphatic sentences.

IMPERSONAL VERBS. In such expressions as "it thunders," "it hails," "it seems," the subject is general and undefined. These verbs are called Impersonal, there being no person expressed or understood as subject. They are always in the third person singular, but they can be of different tenses—e.g. it thundered, it will hail. While *it* is usually employed as the grammatical subject of such verbs, occasionally there is no subject expressed at all; as methinks (=it seems to me), meseems, maybe; also, if you please (=if it please you).

AUXILIARY AND PRINCIPAL VERBS. In the two sentences "I have lost sixpence" and "I have sixpence," there is a great difference in the two uses of *have*. In the first sentence it simply helps to form the present perfect tense of "lose." In the second sentence it has a meaning of its own, namely, "I possess." In the first case it is an auxiliary (helping) verb, in the second a principal verb. The same applies to *shall*, *will*, *may*, *do*, *be*—e.g. "I shall go tomorrow" (*auxiliary*), and "You *shall* (i.e. must) do it" (*principal*). "I will see you before long" (*auxiliary*), and "I *will* have my own way" (*principal*). "It may be wet tomorrow" (*auxiliary*), and "You *may* (i.e. are permitted to) go" (*principal*). "Do you think so?" (*auxiliary*), and "What will you *do*?" (*principal*). "I am coming" (*auxiliary*), and "I *am* a man" (*principal*).

All the above-mentioned verbs (except *have* and *be*), when used as auxiliaries, are deficient in certain tenses. They have no infinitive and no participles and therefore no compound tenses. Of course, when used as principal verbs, they are not necessarily defective. Thus, "to will" (meaning "to resolve") has all the compound tenses "I have willed," etc.

Key to Exercise in Lesson 6

1. I had wanted to see him. 2. Trusting you are well, I remain, yours truly. (In the faulty sentence the participle *trusting* agrees with *you*, which is the suppressed subject to *believe*; it therefore means: "Do you, trusting you are well, believe me," which is nonsense.) 3. The sentence should run either "In *reading* the Psalms" (gerund), or "In the *reading* of the Psalms" (abstract noun). 4. If he had gone (*or*, had he gone), he would have regretted it.

LESSON 8

Some Defective Verbs

THIS Lesson deals with the defective verbs and their uses. Some of their parts were already missing in the Old English period. At this time also they were employed chiefly as auxiliaries, though their uses did not correspond exactly with those of Modern English. In English, auxiliary (or helping) verbs are numerous, and most auxiliaries can be also employed as independent verbs: e.g. *have* meaning *possess*, and *do* meaning *perform*. The two principal auxiliaries, *to be* and *to have*, are conjugated in Lesson 7. Here are the conjugations of the auxiliaries *do*, *will*, *shall*, *may*.

Conjugation of Verb DO

INFINITIVE MOOD

Present	*Incomplete*	*Past*
(To) do	(to) be doing	(to) have done

PARTICIPLES

doing	done

INDICATIVE MOOD

Past		*Present*	
I did	we did	I do	we do
thou didst	you did	thou doest *or* dost	you do
he did	they did	he doeth *or* doth *or* does	they do

NOTES. When used as a notional verb (i.e. a verb expressing a complete idea), *do* is conjugated in full (Future: *I shall do*; Incomplete: *I was doing*); but when as an auxiliary, only present and past indefinite are used (*do* and *did*). *Doest* and *doeth* are used only in the notional sense, e.g. "*Doest* thou well to be angry?" and are now archaic.

Conjugation of Verb WILL

INDICATIVE MOOD

Past	*Present*
I would	I will
thou wouldest *or* wouldst	thou wilt, or willest
he would, etc.	he will, or wills, etc.

NOTES. The past of the subjunctive is the same as the past indicative (*I would*, etc.); there is no present tense in the subjunctive. The forms *willest* and *wills* (Pres. Indic.) are not used when the verb is an auxiliary. When *will* means "to exercise the will," or "to bequeath by will," it has a full conjugation. The past indicative *would* is used as an auxiliary only in reported (or indirect) speech, to take the place of *will* in direct speech, e.g. "he *will* come soon" (*direct*); "he said that he *would* come soon" (*indirect*).

Will is also used to express a customary action, as: "He *will* play for hours"; "When he was young, he *would* spend whole days in the fields." When *will* is an auxiliary verb, it has no compound tenses.

Won't comes from *wol* (not), an old form of *will*.

Conjugation of Verb SHALL

INDICATIVE MOOD

Past	*Present*
I should	I shall
thou shouldst	thou shalt
he should, etc.	he shall, etc.

NOTES. The past of the subjunctive is the same as the past indicative; there is no present subjunctive, nor any infinitive, imperative, or participles, whether *shall* is used as auxiliary or notional verb. The past indicative *should* is used as an auxiliary only in reported speech, representing *shall* in direct speech.

Shall comes from *sculan* = to owe, and hence arose the meaning of obligation, e.g. = "He *shall* do it"; "You *should* answer when your mother speaks." When *shall* retains this idea of obligation it is a notional verb; used as an auxiliary it loses this force.

Conjugation of Verb MAY

INDICATIVE MOOD

Past	*Present*
I might	I may
thou mightest	thou mayest
he might, etc.	he may, etc.

NOTES. The subjunctive mood is the same as the indicative. *May* has no infinitive, imperative, or participles; and in its indicative mood it is never auxiliary, but always notional, e.g. "You *may* go" (i.e. "You are permitted to go"): "The fish *might* be seen rising at any hour almost" (i.e. it was possible to see them). In the subjunctive mood, of course, it can be an auxiliary, e.g. "We eat in order that we *may* live"; "May it be so"; "I came early so that I *might* see you."

Three verbs, *can*, *must*, and *ought*, are sometimes called auxiliaries; but they do not help to form any tense, mood, or voice of any verb. *Can* is from an old verb *cunnan*, meaning "to know." "I can read" therefore means "I know how to read": e.g. "He knew to sing" ("Lycidas"). We have this meaning still preserved in "to con," and in the Scottish "to ken." "Cunning" is the old imperfect participle of this verb, and *couth* the past participle (*cf. uncouth*, which means *unknown* and therefore *strange*).

As *can* originally meant "to know," it required no infinitive; *cf.* "They *can* well on horseback" ("Hamlet"); "Other prayer *can* I none" ("Lay of the Last Minstrel"). Bacon even has "not to *can*."

Can is always a notional or principal verb: e.g. "I *can* write" (i.e. "I am able to write"); "I would if I *could*" (i.e. "I would if I were able").

Conjugation of Verb CAN

INDICATIVE MOOD

Present

I can	We can
Thou canst	You can
He can	They can

Past

I could	We could
Thou couldest *or* couldst	You could
He could	They could

SUBJUNCTIVE MOOD

Present	*Past*
(None)	(Same as Indicative)

No Infinitive, Imperative, or Participles.

Like *can*, the verb *must* is always a notional verb. It has no inflexions for tense or person, all the persons of each number of each of the two indicative tenses being alike *must*. It has no subjunctive, infinitive, imperative, or participles.

Ought is the past indefinite tense of *owe*. In Shakespeare's "Henry IV," the hostess says, "He said this other day you *ought* (= owed) him a thousand pounds." It is now used in the present tense, in the sense of moral obligation, e.g. "I *ought* to be a better man."

Owe originally meant *to own*, *to possess*, as "This is no mortal business, nor no sound that the earth *owes*" ("Tempest"); "I am not worthy of the wealth I *owe*" ("All's Well"). *Owe*, "to be in debt," is quite regular: *I owed*, *I shall owe*, etc.

In the verb *dare* (to venture) the third person singular of the present indicative is properly "he dare," *not* "he dares." The reason is that "I dare" is an old *past* tense and is not really a present at all: e.g. "Mine unworthiness that *dare* not offer," etc. ("Tempest"). "I durst" is now used as the past tense of *dare*, followed by the infinitive without *to* as "he durst not do it." When *dare* is a transitive verb meaning to challenge it is a perfectly regular weak verb.

When *to need* means to lack, to be in want of, it is perfectly regular. But when it means to be under the necessity of doing a thing, the third person singular present indicative is often "he *need*" not "he *needs*," as "he need not go." Contrast this with "he *needs* brains."

Wit (to know) has present, *I wot*, past, *I wist*, and present participle, *witting* or *wotting*. This verb is not used now except in the infinitive *to wit*, in the sense of *namely*; together with *wit*, the verbs *quoth*, *methinks*, *list*, *hight*, *dight* and *worth* are virtually obsolete in Modern English, except in archaic or poetic diction.

Quoth is used only in the first and third persons singular, for "said I," "said he." Examples: "*Quoth* the raven, 'Nevermore,'" "'To tame your fierce temper,' *quoth* she."

Methinks is used only in the forms *methinks* and *methought*. *List* in the archaic *melists* (it pleases me) and *him-listed* is an impersonal verb. It is also used personally as "The wind bloweth where it *listeth*."

Hight is used only in the meaning "was called." *Dight* means, decked, adorned. *Worth*, expressing a wish, is used only in the third person singular present subjunctive, as : " Woe *worth* the day " = " May woe befall the day."

EXERCISE

Explain every *should* and *would* in the following : She would often say " Would I were a man. I *should* have been, for then I would have shown the world a lesson it would never forget." I would reply that I should not attempt to argue with her lest she should get angry ; but I now often think that I should have done so. For perhaps I should have convinced her that it would not have been so easy. Should I, or should I not, I wonder ?

LESSON 9

Strong and Weak Verbs

ENGLISH verbs are divided into *strong* and *weak*, according to the manner in which they form their Past Indefinite tense. Verbs that form this tense by modifying the vowel of the present tense (without adding any suffix) are said to belong to the *strong* conjugation—e.g. *shine, shone.* The past participle of all strong verbs originally ended in *-en*, and this ending still remains in many of them (sometimes in the form of *-n*)—e.g. *break, broke, broken.*

Verbs that form their past indefinite by adding the suffix *-ed*, *-d*, or *-t* to the present tense are said to belong to the *weak conjugation*—e.g. *treat, treated* ; *feel, felt.* When the present tense ends in *e*, *d* only is added—e.g. *love, loved.* The vowel *y* preceded by a consonant becomes *i* before this suffix—e.g. *bully, bullied* ; *pay, paid.* A single final consonant preceded by a single vowel is usually doubled before the suffix—e.g. *drug, drugged* ; *travel, travelled.* The past participle of weak verbs is usually the same in form as the past indefinite. If the present tense ends in *d* or *t*, the suffix is often dropped, and present, past, and past participle have all the same form—e.g. *cost, cost, cost.*

Strong Verbs

The most interesting strong verbs, particularly those that present any difficulty, are given in the Table below, grouped according to vowel modification.

Present	*Past*	*Past Participle*
bind	bound	bound
find	found	found
grind	ground	ground
wind	wound	wound
cling	clung	clung
fling	flung	flung
sling	slung	slung
slink	slunk	slunk
stick	stuck	stuck
string	strung	strung
swing	swung	swung
wring	wrung	wrung
begin	began	begun
drink	drank	drunk (-en)[1]
ring	rang	rung
sing	sang	sung
sink	sank	sunk (-en)[1]
spin	span *or* spun	spun
shrink	shrank	shrunk (-en)[1]
spring	sprang	sprung
stink	stank	stunk
swim	swam	swum
win	won	won
blow	blew	blown
grow	grew	grown
know	knew	known
throw	threw	thrown
draw	drew	drawn
hold	held	held
fall[2]	fell[2]	fallen[2]
lie (to recline)	lay	lain
slay	slew	slain
see	saw	seen
drive	drove	driven
ride	rode	ridden
rise	rose	risen
smite	smote	smitten
chide	chid	chidden, *or* chid
hide	hid	hidden, *or* hid
slide	slid	slid
strive	strove	striven
strike	struck	struck
thrive	throve	thriven
write	wrote	written
bite	bit	bitten
eat	eat (pron. *et*), *or* ate	eaten
beat	beat	beaten
bid (to order)	bade *or* bid	bidden, *or* bid
give	gave	given
forsake	forsook	forsaken
shake	shook	shaken
take	took	taken
come	came	come
bear	bore	borne,[3] *or* born
break	broke	broken
tear	tore	torn
wear	wore	worn
weave	wove	woven
speak	spoke	spoken
steal	stole	stolen
swear	swore	sworn
choose	chose	chosen
freeze	froze	frozen
fly	flew	flown
abide	abode	abode
awake[4]	awoke[1]	awoke[4]
stand	stood	stood
tread	trod	trod, *or* trodden
sit	sat	sat
get	got	got
hang[4]	hung[4]	hung[4]
burst	burst	burst
shoot	shot	shot
seethe[5]	sod	sodden, *or* sod
spit	spat *or* spit	spit *or* spat
fight	fought	fought

Notes

[1] *Drunken, sunken,* and *shrunken* are now used only as adjectives, as : a *drunken* man ; *sunken* rocks ; *shrunken* flannel.

[2] *Fall, fell, fallen* is intransitive ; but the kindred verb *to fell* is transitive, weak and regular, as : "The woodman *felled* the tree."

[3] *Borne* means *carried* ; *born* is used of *birth*, chiefly after the verb " to be." Examples : " Their voices were *borne* by the winds " ; " I was *born* in this village."

[4] *Awake*, as a strong verb, is intransitive, meaning " I wake up." When it is transitive, meaning " I rouse someone," it is weak and has *awaked, awaked* for its past tense and past participle. *Hang* is strong except in the sense of " execute by hanging," when the past tense and past participle are *hanged*, and in such phrases as " hanged if I know."

[5] *Seethe*, meaning *to boil*, is very seldom used now, except in a figurative sense, as : " a seething mass of men." The original sense is seen in the expression, "And Jacob *sod* pottage " (Genesis xxv, 29). The past participle *sodden* now means " soaked through." *Seethe* is now usually weak, making *seethed, seethed.*

Weak Verbs

New verbs which have been introduced into English from foreign sources are conjugated like weak verbs. These include verbs of French origin, such as *passed, finished,* etc., and more scientific borrowings such as *electrified, radiographed,* etc.

Some verbs of the weak conjugation shorten the vowel. Here are examples :

Present	*Past*	*Past Participle*
bleed	bled	bled
breed	bred	bred
feed	fed	fed
lead	led	led
meet	met	met
read	read (*pr.* red)	read (*pr.* red)
speed	sped	sped
light	lit	lit

Others keep the vowel, but change the final *-d* into *-t*.

Present	*Past*	*Past Participle*
bend	bent	bent
lend	lent	lent
rend	rent	rent
send	sent	sent
spend	spent	spent
wend	went, *or* wended	wended
build	built	built, *or* builded
blend	blended	blent
gild	gilt, *or* gilded	gilt, *or* gilded
gird	girt, *or* girded	girt, *or* girded

The following have the same form throughout: *cast, cost, cut, hit, hurt, knit, let, put, rid, set, shed, shred, shut, slit, split, spread, thrust,* and *bid* (meaning "to offer at an auction").

Some shorten or otherwise alter the vowel:

Present	*Past*	*Past Participle*
beseech	besought	besought
buy	bought	bought
catch	caught	caught
bring	brought	brought
sell	sold	sold
seek	sought	sought
teach	taught	taught
think	thought	thought
tell	told	told
work	worked, wrought	worked, wrought
can	could	—
may	might	—
will	would	—
shall	should	—
bereave	bereft (*or* bereaved)	bereft
creep	crept	crept
deal	dealt	dealt
dream	dreamt, *or* dreamed	dreamt
feel	felt	felt
flee	fled	fled
hear	heard	heard
keep	kept	kept
kneel	knelt	knelt
lean	leant, *or* leaned	leant
leave	left	left
lose	lost	lost
mean	meant	meant
sleep	slept	slept
sweep	swept	swept
weep	wept	wept
lay	laid	laid
say	said	said
shoe	shod	shod

The following verbs are of mixed conjugation:

Present	*Past*	*Past Participle*
shear	sheared, shore	sheared, shorn
cleave (to split)	clove, cleft	cloven, cleft
dig	dug, digged	dug, digged
crow	crew[1] crowed	crowed
hew	hewed	hewn, hewed
lade	laded	laden
lose	lost	lost, lorn (*forlorn*)
melt	melted	melted, molten
mow	mowed	mown, mowed
rive	rived	riven, rived
saw	sawed	sawn, sawed
shape	shaped	shapen, shaped
shave	shaved	shaved, shaven
shew, *or* show	shewed, *or* showed	shewn, shown, showed (rare)
sow	sowed	sown, sowed
strew	strewed	strewn, strown, strewed
swell	swelled	swollen, swelled
wax (to grow)	waxed	waxed, waxen
do	did	done
go	(went)[2]	gone

Notes on Mixed Verbs

[1] *Crew* (from *crow*) is rarely used now, and only of the literal crowing of a cock—e.g. "the cock *crew*." When used of the crowing of babies, etc., the past tense is always *crowed*. Some of the strong past participles are used only as adjectives—e.g. a *molten* image, the *cloven* hoof, a *shaven* head.

[2] *Went*, used in the past tense of *go*, is the past tense of *wend*—as in "to wend one's way."

Special Forms. *Clothe*, *have*, and *make* form *clad*, *had*, and *made*, which are contracted from *clothed*, *haved*, and *maked*.

Tight and *straight* (adjectives) are weak past participles of *tie*, *stretch*. *Distraught* is an irregular past participle of *distract*. *Fraught* is the past participle of the obsolete Middle English verb *fraghten*, to load (*cf.* Modern English, *to freight*).

Lie and Lay. Much confusion arises between the verbs *lie* and *lay*, and their differences should be well noted by comparing the principal parts:

Present	*Past*	*Past Participle*
(1) lie (to recline)	lay	lain
(2) lay	laid	laid

To lie is strong and intransitive. *To lay* is weak and transitive.

Examples of *to lie*: The sofa that I *lie* on is comfortable; He *lay* where he fell; I *have* never *lain* on a softer bed.

Examples of *to lay*: Just *lay* the parcel on the table; He *laid* down the book; Hens *lay* eggs; That hen has *laid* five eggs this week.

The use of *lay* with the reflexive pronoun myself (me), etc., as object gives an alternative to (1): I *lay* myself (me) down, for I *lie* down. I *laid* myself (me) down, for I *lay* down. I have *laid* myself (me) down, for I have *lain* down.

LESSON 10

Formation and Use of Adverbs

JUST as adjectives qualify nouns, so Adverbs modify or limit verbs, e.g. "He bowed to me *politely*"; "He gives *twice* who gives *quickly*." This usage has been extended, and adverbs can now modify adjectives and other adverbs in addition to verbs, e.g.: "*Too* many cooks spoil the broth" (*too* modifying the adjective *many*); "It struck me *very* forcibly" (one adverb *very* modifying another, *forcibly*).

Adverbs, like adjectives (from which they are mostly formed), are usually classified according to their meaning, and are divided into qualitative, quantitative, and relational.

1. ADVERBS OF QUALITY: *Well, ill, badly,* and all the adverbs in *-ly* derived from adjectives; *how, however, so, as, likewise,* etc. (sometimes called adverbs of manner).

2. ADVERBS OF QUANTITY: *a.* Degree: *Very, nearly, almost, too, quite, enough, rather, much, more, most, little, less, least, only, but, just, even, any, the* (as in "*the* more *the* merrier").

Also the adverbs of affirmation and negation : *Not, no, nay, ay, yea, yes.*

b. Repetition of Time : *once, twice, thrice, often, seldom, always,* etc.

3. Adverbs of Relation, which show :

a. Time : *Now, then, after, before, soon, ago, instantly,* etc.

b. Place and Arrangement : *Secondly, thirdly, here, there, hither, thither, hence, thence, inside, outside, up, down,* etc. (*Firstly* is not generally acceptable as an adverb : the form *first* is preferable, e.g. " Let us first consider . . . ")

c. Cause and Consequence : *Why, therefore, wherefore, accordingly, consequently,* etc.

It will be noticed that some of the words appearing in this list of adverbs have previously appeared as other parts of speech. *As,* for example, was included under relative pronouns ; and *much, little, no, any,* were included under adjectives. To determine what part of speech a word is in a given sentence, consider the purpose it serves. Thus, " This is the same *as* that " (relative pronoun = " this is the same which that is ") ; "*As* I spoke the sun came out " (adverb denoting the time of the action). Again, " Give him *no* peace " (adjective); " This is *no* better than that " (adverb). Similarly, *much, little,* and *any* before comparatives are adverbs.

Formation of Adverbs

1. From Adjectives. Most adverbs are formed by adding *-ly* to the corresponding adjective—e.g. *wild, wildly* ; *cheerful, cheerfully.* The termination *-ly* = like.

Adjectives ending in *y* preceded by a consonant change *y* into *i* before *-ly* : e.g. *hearty, heartily* ; *speedy, speedily* ; but : *shy, shyly* ; *gay, gaily.*

Adjectives ending in *-le* change the *e* into *y* : e.g. *noble, nobly* ; *horrible, horribly.* When the adjective already ends in *-ly* the same form is generally used for the adverb : e.g. the adverb of *godly* is usually *godly* and that of *leisurely* is *leisurely* : " We should live soberly, righteously and *godly* in this present world." So also *likely* : " A likely story " (adjective) ; " He will very *likely* come " (adverb). Other adverbs derived from adjectives are *once, twice, thrice* (for *ones, twyes, thries*), *unawares.* Some adjectives, in addtion to those ending in *-ly,* are used as adverbs without any change of form : e.g. " run *fast,*" " stand *firm,*" " strike *deep,*" " *pretty* good."

2. From Nouns. *Needs* (as in " If I must needs leave you "), *whiles, sideways, lengthways, straightways, noways,* are genitive cases of nouns. *Whilom* (" at whiles," " formerly ") and *seldom* are dative cases plural of Old English *hwil* (= space of time), and *seld* (= rare). Other adverbs derived from nouns are *headlong, sidelong, piecemeal* (meal = part), *sometimes, always, perhaps, otherwise, midway,* etc. Many adverbs are compounds of the preposition *a* (meaning *on*) and a noun, as *afoot, abreast, aside, asleep* ; while some are compounds of other prepositions with nouns, e.g. *betimes* (by times), *besides, indeed.*

3. From Pronouns. *Thus, then, than* ; *here, hither, hence* ; *there, thither, thence* ; *where, whither, whence* ; *why, how* (for *whow*), and all the other adverbs formed from the relative pronouns, such as *wherefore, whereat, wherein, whereby,* etc.

Those adverbs which are derived from the relative pronouns, with the addition of *as* and *than,* are called *connective* or *conjunctive* adverbs, because they retain the connective power which belongs to relative pronouns. A connective adverb introduces a subordinate clause and modifies the predicate of this clause.

Negative Adverbs

Not is shortened from *nought* or *naught,* and literally means " in no whit, in no degree." In Old and Middle English, *ne* (= *not*) is employed before the verb, and a form corresponding to *naught* after the verb, the two negatives strengthening each other ; thus, in Robert of Gloucester's Chronicle (A.D. 1298) we find "*Ne* be thou naught so sturne " (" Be thou not in any way so stern "), and in Chaucer's " Canterbury Tales " we have

" There was also a Doctour of Physik,
In all the world *ne* was there *none* him like."

Also " Nor hath not one spirit to command " (" Tempest ").

In Modern English, two negatives, so far from strengthening each other, neutralise each other, e.g. " I shall not be nowhere " means " I shall be somewhere."

No and *nay* are from *na,* meaning *never,* while *ay* (affirmative) is from *a,* meaning *ever* (*cf. for aye,* meaning *for ever.* " This world is not for aye," " Hamlet "). *Yes* is from Old English *gese* (pronounced *yĕs-ĕ*), from *gēa* (yea) and *swā* (so).

Comparison of Adverbs

Most adverbs are compared by prefixing *more* and *most* to the positive, as *willingly, more willingly, most willingly.* But a few, and especially those which have the same form as the corresponding adjectives, are formed by the suffixes *-er, -est,* as in the table following :

Positive	*Comparative*	*Superlative*
firm	firmer	firmest
fast	faster	fastest
soon	sooner	soonest
early	earlier	earliest

The following are irregular (see "Comparison of Adjectives," Lesson 4):

Positive	*Comparative*	*Superlative*
well	better	best
badly, evilly, *or* ill	worse	worst
much	more	most
far	farther	farthest
forth	further	furthest
nigh *or* near	nearer	nearest, next
late	later	latest
	latter	last
[rathe, *adjective*]	rather	—
—	ere	erst
lief	liefer	—

Rathe meant *quick, early*; *rather*, therefore, means *quicker, earlier, sooner*. Milton in "Lycidas" has "the *rathe* primrose" (adjective).

Ere is the Old English *ær*, a comparative adverb of time. It is now used mainly as a conjunction. *Erst*, from *ærest*, means *formerly*.

Adverbs are usually placed as near as possible to the words they modify, and generally *before* an adjective, or other adverb, and *after* a verb. For emphasis, however, an adverb may precede the verb, and even be the first word of a sentence.

LESSON 11

Prepositions, Conjunctions, Interjections

A PREPOSITION is a word that shows how things, or their actions or attributes, are related to other things: e.g. "Coming *through* the rye" (*through* showing the relation of the action *coming* to the thing *rye*); "London is full *of* people" (*of* showing the relation of the attribute *full* to the thing *people*). The noun or pronoun following a preposition is in the objective case, governed by the preposition.

Prepositions may be classified as *Simple* and *Compound*. The simple prepositions are *at, by, for, from, in, of, off, on, through, till, to, up, with*.

The most important compound prepositions are:

aboard
about
above
across
against
along
amid(st)
among(st)
(a)round
aslant
astride

athwart
before
behind
below
beneath
beside(s)
between
betwixt
beyond
but (by-out)
down, adown

except
inside
outside
since
toward(s)
underneath

after
over
under
} formed by comptve. suffix *-er*

Beside is used of *place*, to denote either nearness to, or remoteness from: e.g. "They wandered beside the stream" (meaning *by the side of*); "She was almost *beside* herself with grief" (meaning *out of her mind*). When, however, the sense of *over and above* is intended, *besides* is generally used, as "*Besides* Latin, he is also learning Greek."

But is a preposition when it means *except*. It is then followed by the objective case, e.g. "No one was saved but *me*."

Sans and *maugre* are found in Shakespeare, Milton, etc. *Sans* is the French preposition, meaning *without*: e.g. "A confidence *sans* bound" ("Tempest"). Maugre is the French *malgré*, in spite of: e.g. "*Maugre* the Roman" ("Paradise Regained").

Certain participles, such as *considering, concerning, respecting, pending, during, notwithstanding, saving, save*, are often used as prepositions, though they are not really such. Thus, in "*Notwithstanding* your cruelty, I forgive you," the true construction is, "Your cruelty *notwithstanding*, I forgive you," the first three words being in the nominative absolute, and *notwithstanding* filling its proper part as a participle.

Many prepositions are also adverbs, but it is easy to distinguish the two uses. If the word in question governs a noun or some substitute for a noun, it is a preposition: if not, it is probably an adverb. We say "probably," because it might be a conjunction, or even occasionally some other part of speech.

Examples: "He walked *along* the river" (preposition); "He walked *along* very fast" (adverb). "*Since* his death I have lived here" (preposition); "He died long *since*" (adverb); "*Since* he is dead, we must not speak evil of him" (conjunction).

In "But me no buts," *but* is used first as a verb, secondly as a noun.

When *to* is used as an adverb, it is spelt *too* ("It is too cold for you to go out to-day").

A preposition should, if possible, immediately precede the word which it governs. Even in relative and interrogative sentences this order should be observed. It is better to say "Of whom are you speaking?" than "Whom are you speaking of?" When, however, in a relative sentence, the relative pronoun is omitted, the preposition is quite well placed at the end of the sentence, e.g. "He is not a man I am fond of" (i.e. "of whom I am fond").

Obviously, "This is something I will not put up with" is preferable to "This is something up with which I will not put."

Conjunctions

Conjunctions are words which join sentences together—e.g. "I will wait *till* you come." Here *till* joins together the two sentences, "I will wait" and "you come." Not every word that connects two sentences is a conjunction, for relative pronouns (*who, which*, etc.) and relative adverbs (*when, where*, etc.) often connect one sentence with another. With these two exceptions, all words that join sentences together are conjunctions.

The conjunction *and* is peculiar, because, in addition to joining two sentences, it can also join two words, provided they are both of the same kind and stand in the same relation to some other word in the sentence : e.g. "Two *and* two are four," "Egg *and* milk make a good mixture." But in a sentence like "My parents and my cousins are here," *and* joins two *sentences* ("my parents are here" and "my cousins are here"), not two *words*.

Conjunctions are divided into *co-ordinative* and *subordinative*. Those in the former class join co-ordinate sentences, that is, sentences of the same rank (Latin *ordo*=rank), neither of which is dependent on the other. The co-ordinative conjunctions are *and, both, but, either, or, neither, nor* (and, according to some grammarians, *because, for, as*, and *whether*).

Either is the distributive pronoun, and *whether* the relative pronoun, used as conjunctions : e.g. "*Either* of the two will suit me" (pronoun) ; "*Either* you or I must perish" (conjunction).

But was originally a preposition, meaning *without, except*. In phrases like "I cannot but think," "There is no one but knows," it is a conjunction ; also in all cases where it joins two sentences, as "Strike, but hear me," "He loved not fatherland, but himself."

Subordinate conjunctions join subordinate clauses to a main clause, i.e. they unite sentences one of which is dependent on the other ; e.g. "He'll kill himself yet, *though* he has been lucky so far." Here, the second clause depends on the first, or is subordinate to it, therefore the conjunction uniting them is subordinative. Such a sentence as the above is called a *complex* sentence, as opposed to a compound sentence, which consists of two or more co-ordinate clauses united by a co-ordinative conjunction. In a complex sentence, one clause is called the principal clause, and all the other clauses are called subordinate. These subordinate clauses play the part of adverbs, adjectives, or substantives, and are called accordingly, *Adverbial, Adjectival*, or *Substantival Clauses*.

The most important subordinative conjunctions are :

1. *That*, introducing substantival clauses : e.g. "He said that he was cold."
2. *If, unless, except*, etc. (conditional).
3. *Though, although, albeit* (concessive).
4. *That*, meaning "so that" (consecutive) as : "It was so cold that the water froze."
5. *That*, meaning "in order that," *lest* (final) as : "He went out that he might get warm."
6. *After, before, till, until, ere, since, now, while, as* (temporal).
7. *Because, since, for, as* (causal).
8. *Than* (comparative).

Than is now regarded as a conjunction, though it is strictly a relative adverb, meaning *when, at which time*. The noun or pronoun following *than* may be in the nominative case or in the objective, according to the predicate to be supplied, thus : "I know you better than he (does)"; "I know you better than (I know) him"; "He hates me more *than* you" may mean "He hates me more than he hates you" (*you* being objective), or "He hates me more than you hate me" (*you* being nominative). A relative pronoun following *than* is always put in the objective case, even when it is strictly nominative, as : "Caesar is dead, than *whom* no greater Roman ever lived." *Whom* ought to be in the nominative, as the sentence stands for "Caesar is dead, and no greater Roman than *he* ever lived."

Interjections

These are words interjected or "thrown in" to express some emotion. They do not stand in any grammatical relation to other words, and are independent of the construction of the sentence.

Examples : *Hurrah! Alas! Oh! Ah! Pshaw! Ha, ha! Good-bye!* (God be with you) *Hullo! Whoa! Welcome! Hail!*

LESSON 12

Analysing the Sentence

Words can be considered not only as independent units (the study of *Accidence*) and parsed as such, but also in their relationship to other words grouped with them to form a sentence (the study of *Syntax*). The unit of speech is the sentence, and it is quite as important to be able to break up a sentence into its component parts as, i.e. to be able to compare an adjective or conjugate a verb. To parse a word is to say to what part of speech it belongs ; and this cannot properly be done until it is seen in the context of a sentence, and until the sentence has been mentally broken up, or analysed. The practice of analysis, then, logically comes before that of parsing.

A simple sentence has only one subject and one predicate. The subject is that about which something is asserted ; the predicate is what is asserted concerning the subject. In every sentence there must be a subject and a predicate ; this is the irreducible minimum, as in “ Fire burns.” In addition, there may be a word or words limiting or qualifying either the subject or the predicate, or both, as in “ *This* fire burns *well.*” Finally, if the predicate contains a transitive verb, this will take an object, and this object, too, may have a word or words limiting it, as in “Fire burns your finger” (*finger* being the object and *your* the limitation of the object).

As a rule, a simple sentence does not consist of more than the following parts : subject ; limitation of subject ; predicate ; limitation of predicate ; object ; limitation of object.

For example : “ The freshening breeze of eve unfurled that banner's massy fold ” consists of five parts, which may be isolated as in the table given on this page.

Sometimes the predicate consists of a verb and a complement especially with verbs of *making*, *calling*, and so on. For instance, the sentence given in our third example of analysis of simple sentences : “ Cromwell's enemies have often called him a bloodthirsty monster.”

Analysis lays bare the structure of the sentence. From a grammatical point of view, a sentence is not grasped until it has been mentally analysed and all its component parts set forth in their nakedness.

It is only another step to the dissection of a sentence containing a principal clause and one or more subordinate clauses, i.e. a complex sentence. To analyse this one first picks out the principal clause, and inserts the subordinate clauses as parts of the sentence. Then, with the omission only of the connecting words, the different subordinate clauses can be analysed in turn. The student should be familiar with the various kinds of clause. There are three kinds of subordinate clause :

(1) SUBSTANTIVAL. Clauses that play the part of a substantive in relation to some part of the sentence. Examples : “ We know *that you are wrong* ” (this clause is the object of “ know”) ; “ *When the election will come* is uncertain ” (this clause is the subject of “ is ”).

(2) ADJECTIVAL. Clauses that play the part of an adjective in relation to some part of the sentence. Examples : “ Give me the portion of goods *that falleth to me* ” (qualifies “ portion ”); “ That is the spot *where Nelson fell* ” (qualifies “ spot ”). Care must be taken, however, to distinguish such clauses from clauses involving an indirect question—as : “ Tell me *where Nelson fell*,” “ I asked *where I was*,” “ I know *why you have come*.” In these sentences the dependent clauses are substantival, representing substantives ; there is no antecedent to which they could relate.

Analyses of Simple Sentences, Showing their Structure

“ The freshening breeze of eve unfurled that banner's massy fold.”

Subject	*Limitation of Subject*	*Predicate*	*Object*	*Limitation of Object*
breeze	1. The freshening 2. of eve	unfurled	fold	that banner's massy

“ Here rests his head upon the lap of earth,
A youth to fortune and to fame unknown.”

Subject	*Limitation of Subject*	*Predicate*	*Limitation of Pred.*	*Object*	*Limitation of Object*
youth	1. A 2. to fortune and to fame unknown	rests	1. Here 2. upon the lap of earth	head	his

“ Cromwell's enemies have often called him a bloodthirsty monster.”

		Predicate				
Subject	*Limitation of Subject*	*Verb*	*Complement*	*Limitation of Complement*	*Limitation of Predicate*	*Object*
enemies	Cromwell's	have called	monster	a bloodthirsty	often	him

Analyses of Complex Sentences

(1) “ There is some soul of goodness in things evil would men observingly distil it out.”					
Subject	*Limitation of Subject*	*Verb*	*Limitation of Verb*	*Object*	*Limitation of Object*
soul	(*a*) some (*b*) of goodness	is	(*a*) in things evil (*b*) would men observingly distil it out	—	—
men	—	would distil	(*a*) observingly (*b*) out	it	—
(2) “ If you catch him when you reach home, give him the message which I will give you now.”					
(you)	—	give	(*a*) him (*b*) if you catch him when you reach home	message	(*a*) the (*b*) which I will give you now
(*a*) “ If you catch him when you reach home.”					
you	—	catch	when you reach home	him	—
(*b*) “ When you reach home.”					
you	—	reach	home	—	—
(*c*) “ Which I will give you now.”					
I	—	will give	(*a*) you (*b*) now	which	—

(3) ADVERBIAL. Clauses that play the part of an adverb in relation to some part of the sentence. Examples : " I like her *because she is cheerful*" (modifying "like") ; " Do *as I tell you*" (modifying " do ").

Sentences must always be grouped according to their subordination or co-ordination. Example :

There at the foot of yonder nodding beech
That wreathes its old fantastic roots so high,
His listless length at noontide would he stretch,
And pore upon the brook that babbles by.

He would stretch his listless length at noontide, there, at the foot of yonder nodding beech. *Principal.*

And (he would) pore upon the brook. *Co-ordinate Principal.*

That wreathes its old fantastic roots so high. *Subordinate Adjectival, qualifying " beech."*

That babbles by. *Subordinate Adjectival, qualifying* " brook."

The formal analysis in the second table shows the structure of the following sentences :

(1) " There is some soul of goodness in things evil
Would men observingly distil it out."

The principal clause is " There is some soul of goodness in things evil," and the subordinate clause " (If) men would observingly distil it out."

(2) " If you catch him when you reach home, give him the message which I will give you now."

The principal clause is " give him the message " ; the other three clauses are subordinate.

LESSON 13

Simple Schemes in Parsing

THIS Course in the English Language has now taken the student through all the parts of speech in detail, and he has been " parsing " words, perhaps unconsciously, throughout the process. For to " parse " a word is simply to say to what part of speech it belongs, and how it is related to other words in the same sentence. The following is a parsing scheme :

1. NOUN. Give (1) general class—i.e. proper, common, abstract, collective ; (2) gender ; (3) number ; (4) case ; (5) reason for the case.

2. ADJECTIVE. Give (1) class, whether of quality, quantity or relation ; (2) degree, whether positive, comparative or superlative ; (3) its qualification of the substantive. If the adjective in question is pronominal—i.e. also used as a pronoun—state this in parsing it.

3. PRONOUN. Give (1) class ; (2) gender (if possible) ; (3) number ; (4) case, with reasons for the number and the case.

4. VERB. If a finite verb, give (1) voice ; (2) mood ; (3) tense ; (4) number ; (5) person and the subject with which it agrees or the object it governs ; (6) principal parts—i.e. present indicative, past indicative and past participle.

If an infinitive or gerund, give (1) voice ; (2) tense ; (3) case, with a reason for the case.

If a participle, give (1) voice ; (2) tense ; (3) number ; (4) case, and the substantive with which it agrees. In *all* moods, say whether the verb is transitive or intransitive, whether of weak conjugation or of strong, and give the principal parts.

5. ADVERB. Give (1) class ; (2) degree ; (3) what it qualifies.

6. PREPOSITION. State what it governs.

7. CONJUNCTION. Give its class, and say what sentences or words it connects.

It should be noted that all grammarians do not adopt precisely the same nomenclature. Some insist that adjectives " qualify " but adverbs " modify." Such distinctions are not vital, and the student should not attach too much importance to them. It is important, however, to note that a word is not necessarily one *fixed* part of speech, but differs according to its function. Thus " frequent " is an adjective in " It is a frequent occurrence " and a verb in " We frequent the same club." Similarly in "Sleeping is necessary for life," and "Let sleeping dogs lie," sleeping is a gerund in the first example and an adjective in the second.

Example of Parsing

"*But then the mind much sufferance doth o'erskip,
When grief hath mates, and bearing fellowship.*"
(" King Lear.")

But. Co-ordinative conjunction, connecting this sentence with what has gone before.

Then. Adverb of time, modifying " doth o'erskip."

The. Demonstrative adjective (sometimes called definite article), pointing out " mind."

Mind. Abstract noun, neuter, singular, nominative because subject of " doth o'erskip."

Much. Adjective of quantity, positive, qualifying " sufferance."

Sufferance. Abstract noun, neuter, singular, objective, governed by " doth o'erskip."

Doth o'erskip. Verb, transitive, weak conjugation, active, indicative, present, singular, third person, agreeing with its subject " mind," from *o'erskip, o'erskipped, o'erskipped.*

When. Relative adverb (or conjunctive adverb) of time, modifying " hath."

Grief. Abstract noun, neuter, singular, nominative because subject to " hath."

Hath. Verb, notional (not auxiliary here), transitive, weak, active, indicative, present, singular, third person, agreeing with its subject "grief," from *have, had, had.*

Mates. Common noun, common gender, plural, objective after "hath."

And. Co-ordinative conjunction, joining the two sentences "grief hath mates," and "bearing (hath) fellowship."

Bearing. Abstract noun, neuter, singular, nominative, subject to "hath" understood.

Fellowship. Abstract noun, neuter, singular, objective after "hath" understood.

NOTE. Parse compound tenses of a verb: e.g. *have been, shall be leaving*, all as one word. We could, of course, parse the words separately, but there is no need to do this.

EXERCISE

Parse fully the words in italics: "And *so*, neither condemning the delights of *others*, nor altogether *distrustful* of our own, we must *advance*, as we live *on*, from what is promised to what is *fulfilled*."

LESSON 14

Notes on English Punctuation

PUNCTUATION is the right method of inserting stops (Latin *puncta*, points). Stops are written marks to represent oral pauses.

The meaning of a sentence ought to be plain without the aid of any stops whatever. Stops are a comparatively modern invention; they do not appear on ancient manuscripts, and at one time they were not allowed in our Acts of Parliament. At the present day in legal documents stops are most often conspicuous by their absence.

Very often the entire meaning of a sentence can be altered by a slight alteration of punctuation—a fact of which full advantage is taken in many riddles that are propounded, and in many traps that are set for the unwary. Thus, in the well-known statement, "King Charles walked and talked half an hour after his head was cut off," nonsense becomes sense by the insertion of a colon after "talked."

FULL STOP. This is used to mark the completion of a whole sentence, whether simple or complex. It is also used after abbreviations: e.g. R.S.V.P., Rev., M.P., *nem. con.*, Dr., Mr.

COLON. The *colon* originally marked off the parts of a compound sentence. It is now used after a sentence which, though grammatically complete, is followed by another closely connected in sense; here a full stop would mark too great a break. For example:

"Cowards die many times before their deaths:
The valiant never taste of death but once."

A colon is also used to introduce a list or tabulation, or a quotation.

SEMI-COLON. This is a modern and somewhat weak form of the colon. It is impossible to lay down rules for their respective use, but, as a generalisation, it may be said that the semi-colon marks a less complete pause than the colon. The semi-colon is frequently placed between the co-ordinate members of a compound sentence *when the connexion is marked by a conjunction*, as: "You do not understand the lessons you have learnt; but this is only because you are inattentive." If the sentences are short, and closely connected in meaning, commas are used rather than semi-colons, as:

"We carved not a line, and we raised not a stone,
But we left him alone in his glory."

COMMA. The *comma* is not used as frequently as it once was. A sentence should not be overloaded with commas; they should be used only where it is absolutely necessary for the sake of clearness. Common sense must be the guiding element in their usage. But a few points may be mentioned:

1. A comma is desirable to mark the end of a substantive clause forming the *subject* of a verb, e.g. "That the days are longer in summer than in winter, admits of no dispute." But if the clause either follows the verb, or is the object of the verb, no comma is used, e.g. "He said that he was cold."

2. In a list of words of the same nature—nouns, adjectives, adverbs, etc.—brought together in the same connexion, a comma is inserted after each word except (sometimes) the penultimate when it is followed by "and" or "or", e.g. "The fence was painted in stripes of green, brown, black and white." But the omission of the comma before "and" and "or" so often leads to ambiguity that an increasing number of good writers now insert another comma, e.g. "Tom, Dick, and Harry," "this, that, or the other."

3. The comma is used after an adverbial clause that comes before the verb which it modifies, as: "When he comes, tell me." But if the adverbial clause *follows* the verb, the comma is not needed, as: "Tell me when he comes."

4. There is no need of a comma between the antecedent and the relative pronoun if the relative introduces a limiting, or restricting, clause; but if the relative is continuative or ampliative a comma must be introduced.

Restrictive. "He broke the pen which I lent him."

Continuative. "His eldest son, whom he had lost many years before, had always been his favourite."

5. A comma is used to separate a noun in the vocative (or nominative of address) from the rest of the sentence, e.g. " Mother, may I go out to play ? "

OTHER STOPS. The *note of interrogation* (?) is placed at the end of all direct questions, e.g. " Who is there ? " It is not used after an indirect or reported question, e.g. " He asked who was there."

The *note of exclamation* (!), used after interjections and exclamations, e.g. "Alas ! " is also sometimes used after the vocative case, e.g. "All hail, great master ! " It is sometimes used instead of a full stop at the end of a sentence purely for emphasis, or to convey an effect of surprise ; but this is not a practice to be encouraged—nor is the mark intended, as is often vulgarly supposed, to denote a jest. On the other hand, it should always be used after such exclamatory sentences as " How absolute the knave is ! " " What a lovely day it was ! "

Curved and square brackets, ( ), [ ], are used to separate certain words from the rest of the sentence, to add an explanation of a difficult word, etc.

Inverted commas, double " — ", or single ' — ', are used to mark quotations. When a quotation occurs within a quotation the inner quotation should be carefully rendered distinct by single inverted commas inside double, or double inside single, as :

" Breathes there the man with soul so dead,
Who never to himself hath said,
' This is my own, my native land ' ? "

LESSON 15

On the Writing of Good English

THE main object of the study of the English language is that one may be able to express oneself clearly in it, whether in writing or in speech. The student should aim not only at meaning exactly what he says, but also—and this is all-important—at saying exactly what he means.

Absolute clearness of style is the result of long and careful discipline, but it is a result that will well repay the labour. It can be cultivated better in writing than in speech, because what is written can be revised, whereas the spoken word is usually forgotten as soon as uttered. Make it a practice at first to read and re-read everything that you write, looking carefully for any ambiguity or any loophole for misunderstanding. If a statement is not quite clear to the writer of it, the chances are that it will be far from clear to anyone else.

Perhaps in no matter is this more important than in one where it is as a rule most neglected—that of writing business letters. The necessity for a clear style is a very practical matter indeed, as thousands of people have discovered.

It is impossible to mention all the errors of style that can be committed, but the following are the most common.

(1) Words are often left without any relation whatever. Examples : " Your guilt is as great or greater than his," where *as* has nothing to which to relate. The correct version is " Your guilt is as great as or greater than his " or, preferably, " Your guilt is as great as his or greater."

" He is not only acquainted, but well versed in English literature," where *acquainted* should be followed by *with*, to bring it into relation with the rest of the sentence.

" Having crossed the stream, the banks on either side fell in," where *having crossed* has no relation to any other word of the sentence. As it stands, it agrees with *banks* : but the banks did not cross the stream.

" Alarmed at the appearance of the sky, a terrific peal of thunder shook the house, so that he ran out," where *alarmed* is not related to any other word. Grammatically, it agrees with *peal of thunder*, but it was not the peal of thunder that was alarmed. The subject of the main sentence should, of course, be *he*.

(2) Many errors arise from a wrong or misleading *order* of words. As a rule, a sentence should run in its natural order : subject (and its limitations), predicate, object (and its limitations), adverbial limitations of the predicate—e.g. " The dying hero spoke words of consolation and of cheer in the midst of his mortal agony." For the sake of emphasis, e.g. " Great is Diana of the Ephesians," or for certain other reasons, the order may be altered. But whatever be the order of the words the important point is that the meaning shall be clear.

Great care is needed in dealing with relative pronouns, lest they seem to refer to a substantive which is not intended to be their antecedent. For example : " Much energy was displayed by Mr. Smith in running down the street after his silk hat, which he felt might have been devoted to a better purpose." The only way of avoiding this pitfall is to place the antecedent *immediately* before the relative : " Mr. Smith, in running down the street after his silk hat, displayed an amount of energy," etc.

Equal care is necessary in dealing with adverbs or adverbial phrases, as these have an awkward knack of appearing to qualify words which they are not intended to qualify. Examples : " The Moor seizing a bolster full of rage and jealousy smothers her."

" Erected to the memory of John Phillip accidentally shot as a mark of affection by his brother."

" The young man coloured with pleasure and promised to return in quite a gratified tone of voice."

" You have already been informed of the sale of Ford's theatre where Mr. Lincoln was assassinated for religious purposes."

(3) Further errors of style are : the use of unnecessary phraseology for simple words, e.g. " the nasal organ " (for nose), " the lower extremities " (for legs), " the tender passion " (for love) ; the use of stereotyped expressions (clichés), hackneyed allusions and quotations, e.g. " fit as a fiddle," " the Swan of Avon," " the cup that cheers but not inebriates " ; and the use of needlessly involved sentences, meaningless phrases, and abstract instead of concrete nouns.

A typical specimen of this kind of writing is the following extract from a newspaper article, reprinted in H. W. Fowler's " The King's English " :

> One of the most important reforms mentioned in the rescript is the unification of the organization of judicial institutions and the guarantee for all the tribunals of the independence necessary for securing to all classes of the community equality before the law.

Sir Arthur Quiller-Couch, in " The Art of Writing," presses the point well home by re-writing in what he calls " jargon " the first nine lines of Hamlet's soliloquy " To be or not to be " (Hamlet, Act III, scene i) :

> To be, or the contrary ? Whether the former or the latter be preferable would seem to admit of some difference of opinion ; the answer in the present case being of an affirmative or of a negative character according as to whether one elects on the one hand to mentally suffer the disfavour of fortune, albeit in an extreme degree, or on the other to boldly envisage adverse conditions in the prospect of eventually bringing them to a conclusion. The condition of sleep is similar to, if not indistinguishable from, that of death ; and with the addition of finality the former might be considered identical with the latter : so that in this connection it might be argued with regard to sleep that, could the addition be effected, a termination would be put to the endurance of a multiplicity of inconveniences, not to mention a number of downright evils incidental to our fallen humanity, and thus a consummation achieved of a most gratifying nature.

As a mental training the art of reading the English classics aloud is worth cultivating. Clearness depends on grasping the author's meaning, and then conveying that meaning adequately to others. Correct emphasis is essential, and monotony must be avoided by proper inflexion of the voice.

While it is highly important in the formation of style to read the great masters of English literature, it should be remembered that each person has a natural style of his or her own. The study of the great stylists should therefore be with the aim of perfecting the reader's particular style rather than with the idea of slavish imitation.

LESSON 16

Paraphrasing and Précis Writing

A PARAPHRASE is the free rendering of a text into a clearer and fuller form than found in the original. Paraphrasing is a stimulating but difficult exercise which calls for exactness of vocabulary and concentration. An effort has to be made to penetrate exactly into the writer's thought so as to reproduce only what has been written. The student may find considerable difficulty at first, but with practice and as reading increases his vocabulary a steady improvement may be confidently expected.

Certain rules can be laid down as a help. (1) Always read through the original three or four times to make sure you have understood the author's idea. Try to reproduce the tone of the original passage. (2) There is no need to find a synonym for every word, though it is advisable to do so if a synonym makes the meaning more clear. You must avoid making a paraphrase of a piece of verse consist of the same words written in a prose order. The thought in poetry is sometimes more compressed, sometimes more diffuse, than in prose. It is your business to make the meaning clear. (3) Do not hesitate to cut up long sentences into shorter ones. (4) As a rule your paraphrase will be longer than the original, but be as brief as possible. (5) The paraphrase should be a piece of prose intelligible to anyone who has not read the original. (6) Sometimes the paraphrase takes the form of changing a piece of archaic English into modern prose and spelling. You must look out for words which have changed their meaning. Thus " presently " in Shakespeare's time meant " now," " at present," whereas to-day it means " soon."

Examples of Paraphrasing

One exercise from verse and one from prose will make the process clear.

> Perhaps in this neglected spot is laid
> Some heart once pregnant with celestial fire :
> Hands, that the rod of Empire might have swayed,
> Or waked to ecstasy the living lyre.

Perhaps in this uncared-for spot is buried some being filled once with heavenly ardour ; hands which, had chance been otherwise, might have grasped the sceptre of an empire, or drawn exquisite music from some instrument.

Here is the opening of Bacon's essay on Gardens. Notice the magnificent opening sentence is retained in the paraphrase.

> God Almightie first Planted a Garden. And indeed, it is the Purest of Humane pleasures. It is the Greatest Refreshment to the Spirits of Man; Without which, Buildings and Pallaces are but Grosse Handy-works: and a Man shall ever see, that when Ages grow to Civility and Elegancie, Men come to Build Stately, sooner then to Garden Finely: As if Gardening were the Greater Perfection. I doe hold it, in the Royall Ordering of Gardens, there ought to be Gardens, for all the Moneths in the Yeare: In which, severally, Things of Beautie, may be then in Season.

> God Almighty first planted a garden. In truth gardening is the most unmixed of human pleasures. It is most refreshing to the mind of man, for without it all his fine buildings and palaces appear but unfinished work. As time goes on and we grow more civilized and tasteful, it will be found that men can build in noble fashion earlier than they can become skilled gardeners. By this it appears that gardening is the more difficult calling. I believe that in the arrangement of royal gardens there should be gardens for each month in which beautiful things are at their best as they come into season.

Précis Writing

A précis is an abstract, abridgement, or summary. It is the term usually applied to a condensed report or narrative. The object of a précis is to enable anyone who reads through the digest to obtain a knowledge of the essential features of the matter of which it is a condensation. The journalist makes a précis of a minister's speech to enable readers to see at a glance its main points. The student takes lecture notes to make a précis of what he has heard. A business clerk may be called upon to prepare a précis from a mass of correspondence, and government clerks have constantly to present précis of documents for the use of ministers.

Précis writing is an excellent exercise in extracting the essential matter from books, documents, speeches, etc. It requires discrimination, tidiness of mind, and powers of compression. The following rules should prove useful in practice.

(1) Be sure to master the subject-matter which you have to summarise. If you cannot do this in one reading, read it a second or third time, and make certain that you keep to the logical order of the thought.

(2) When you feel that you have mastered the passage, read it once again and underline the important passages. Then prepare a skeleton outline of your précis.

(3) Go over your outline again and strike out everything that does not now appear essential.

(4) You are frequently asked to suggest a suitable title, and to reduce the original matter to about one-third. This is usually a reasonable reduction and should present no undue difficulty.

(5) Be brief, but not telegraphic. Your final draft should read as a piece of continuous prose which conveys clearly all that is necessary of the original.

(6) Letters and speeches should always be given in the past tense and the third person. Direct quotation must be changed into reported speech. Never reproduce in a précis the actual words of the speaker. Conversation should be briefly summarised.

(7) Connect sentences together by linking words such as "therefore," "while," "thus," etc., and cut out all repetition used for emphasis.

Example of Précis Writing

Give a title and reduce the following specimen to about one-third:

> Who will ever be able to forget the heroic self-sacrifice shown by an English regiment drowned in a shipwreck? On Feb. 25th, 1852, the transport "Birkenhead" was carrying troops to reinforce the garrison at the Cape of Good Hope. The ship struck a hidden rock off Cape Agulhas, the most southern point of Cape Colony. She carried 500 soldiers, a crew of 134, a number of women and children, and some passengers who were invalids. Officers and men took their arms and drew up in battle line on the deck as calmly as if on parade on a barrack square in England. Such rescue work as was possible proceeded as the ship sunk slowly beneath the waves. There were hardly sufficient lifeboats to carry the women, children and the sick, and none to accommodate the troops. Not one of the strong, vigorous and fully armed young men stepped from the ranks and attempted to take the place of those going to apparent safety, and the entire regiment was swallowed up in the deep waters, martyrs to obedience and self-sacrifice. Only 192 people were saved. The name of "Birkenhead," and the date of the wreck, should be placed on the colours of this regiment in commemoration of a deed as truly glorious as the most brilliant of victories on the battle-field.

HEROISM ON THE "BIRKENHEAD"

> The self-sacrifice on the "Birkenhead" is unforgettable. The transport, with reinforcements for the Cape, struck a rock when carrying 500 troops, a crew of 134, women, children and invalids. The troops, drawn up in battle-order on the deck, went down with the ship. Lifeboats were insufficient to accommodate non-combatants, but no armed man attempted to escape, and the entire regiment was drowned. The name "Birkenhead" should be placed on the regimental colours to perpetuate a deed as glorious as the most brilliant victory.

BOOK LIST

The Making of English, H. Bradley (Macmillan); *A Short History of English*, H. C. K. Wyld (Murray); *History of Modern Colloquial English*, H. C. K. Wyld (Blackwell); *Our Language*, Simeon Potter (Pelican Books); *Words and Idioms*, L. Pearsall Smith (Constable); Crabb's *English Synonyms* (Routledge); *On the Art of Writing*, Sir A. Quiller-Couch (C.U.P.); *The King's English*, H. W. and F. G. Fowler (Oxford); *Modern English Usage*, H. W. Fowler (Oxford); *Good English* and *Better English*, G. H. Vallins (Pan Books); *Plain Words* and *The ABC of Plain Words*, Sir Ernest Gower (repub. in one vol. as *The Complete Plain Words*, H.M. Stationery Office).

A good dictionary is also indispensable for the serious student, e.g. The Concise Oxford, Chambers's Twentieth Century, Nuttall's Standard, Wyld's Universal.

MECHANICS

To the average student Mechanics is a subject of unrelieved dullness. In this Course a definite attempt has been made both to clarify the subject and make clear its real importance as the effective basis of our highly mechanised civilization. Without a working knowledge of the laws of Mechanics, so apparently simple in statement but increasingly complicated in application, the work of engineers and constructors of every kind becomes unsound and even the workshop of the amateur mechanic is ill equipped.

This Course is designedly brief but highly practical. For associated aspects of the subject, the student is referred to PHYSICS *in Vol.* 2, *and for Mechanics in practice to* ENGINEERING *in Vol.* 5.

10 LESSONS

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LESSON 1

Introduction to Kinematics

MECHANICS is probably one of the oldest sciences in existence and originally was applied to the study and design of contrivances or " machines " used for raising heavy weights beyond the range of manual power. The monumental task of erecting the world-famous Pyramids of Egypt, or to take an example nearer home, the building of Stonehenge on Salisbury Plain, where the gigantic blocks of stone are said to have been transported from South Wales, are outstanding illustrations of the application of mechanics in very early days.

In common parlance the term mechanic persists to-day in reference to the man who makes or repairs machines.

The application of the fundamental laws of nature as applied to machines was not seriously developed into a consistent theory until about A.D. 1600, when the Italian astronomer Galileo Galilei (1564–1642) first investigated and developed the laws associated with motion, and later the greatest genius of all, Sir Isaac Newton (1642–1727), propounded his famous three " Laws of Motion " in his *Principia* (1687). These laws are now accepted as the basis of Mechanics and have survived the closest scrutiny of the German-born American physicist Albert Einstein (1879–1955).

Force, Matter, and Motion

It is to the study of the relationships existing between *force*, *matter*, and *motion* as outlined by Newton that this series of Lessons is directed.

Experiment forms a large part of the study, and it is indisputably agreed that all these theoretical speculations should be verified by the student as he proceeds. It is quite unnecessary to depend upon expensive apparatus and elaborate laboratories. These laws can be demonstrated quite simply and conclusively with very elementary material.

Mechanics is conveniently divided into two distinct sections :

Dynamics, which deals with bodies in Motion, as for example crankshafts, flywheels, and locomotives.

Statics, which treats, as the name implies, with bodies remaining at rest under the action of Forces, as, for example, cranes, bridges, and earth-retaining walls.

In the Dynamics section the motion of the body is first observed purely from the point of view of motion only, and this branch is called *Kinematics*—the measurement of motion. Secondly, the effects of motion on various bodies are investigated under the title of *Kinetics*.

It is within the experience of everybody that an indiarubber ball caught by the hand when flying through the air does not affect the hand to the same extent as a leather cricket ball, although both balls may at the time of reaching the hand *have the same motion*. It is equally apparent that a train weighing 800 tons proceeding at 30 miles an hour and being brought into sudden collision with buffer stops will do more damage than a bicycle of perhaps 15 lb. weight striking a wall at the *same speed of* 30 *miles an hour*. It is evident that the *mass* or *quantity of matter* in these bodies bears some relation to the effect produced when they are suddenly brought to rest. The attention is then first directed towards the study of Kinematics.

Speed and Velocity

The common term used for motion is speed, in feet moved through every second of time (feet per second) or miles every hour (miles per hour) or, more generally, units of distance in units of time. This term speed, however, does not necessarily indicate any particular direction, and the more scientific term *velocity* is used; this expresses at the same time a magnitude and a direction.

Velocity is, then, a rate of change of position in a specified direction. As indicated, the units of distance may be feet, land miles, sea miles, kilometres, etc., and the units of time, seconds, minutes, hours, etc. A nautical mile (6080 feet) covered in one hour is a knot; thus a knot is a velocity or a speed according to whether the direction is specified or not.

A knot may therefore be expressed as :

One nautical mile per hour, or,
6080 feet in 3600 seconds, or,

$$\frac{6080}{3600} = 1{\cdot}69 \text{ feet per second.}$$

Similarly, a train running due north and covering a distance of 60 miles every hour has a velocity of :

60 miles per hour, or,
60 × 5280 feet every 3600 seconds, or,

$$\frac{60 \times 5280}{3600} = 88 \text{ feet per second.}$$

The velocity may be *uniform*, in which case the body travels equal distances in equal increments of time (however small these times may be) in a fixed direction—in effect a straight line.

Also the velocity may be *variable*, since in practice it is not usual for a body to maintain a constant uniform velocity for any great length of time. In these circumstances when the velocity is changing, it will be travelling at any one velocity at a certain instant, and this velocity is referred to as the body's instantaneous velocity at a specific time. Assuming that the distance from London to Peterborough is 75 miles and that an express train takes 1½ hours to complete the journey, then the *average* velocity $= \frac{75}{1 \cdot 5} = 50$ m.p.h. (miles per hour). It is clear that the train must start from rest, i.e. zero velocity; it will increase speed on the straight, slow down for stations, curves in the track, etc., and at the end of the journey it will finish again at zero velocity. Therefore, to have maintained an average velocity of 50 m.p.h., the train must have reached at times an instantaneous velocity considerably above this.

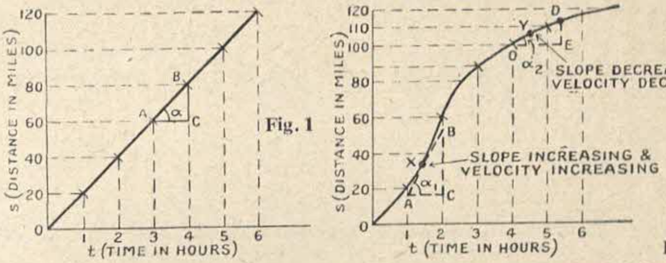


Fig. 1 **Fig. 2**

Fig. 1, on the left, shows a time-distance graph of uniform velocity. Compare this with Fig. 2 (right), a time-distance graph of variable velocity.

Considering uniform velocity first, this may be simply expressed in symbols as follows:

If s is the distance travelled and v the uniform velocity maintained throughout a time t then,

$$s = vt$$

or dividing across by t, $\frac{s}{t} = v$

This may be illustrated by means of diagram or graph, using the vertical ordinates to represent distance in miles, the horizontal abscissae to represent time in hours. In such a distance-time graph of uniform velocity as shown in Fig 1, it can be seen at once that the body has moved 20 miles in the first hour, 20 miles in the second, and so on.

Taking any two points A and B on the graph it will be seen that the measurement AC under AB corresponds to one hour of time while the measurement BC corresponds to a distance of 20 miles,

and since $\frac{s}{t}$ equals v

velocity is represented on the diagram by $\frac{BC}{AC}$

which is the tangent of the angle α, or the slope of the line between A and B.

Thus the slope of the distance-time graph between any two points gives the velocity between these points. This diagram shows uniform velocity, and it follows that the slope is constant and that a straight line intersects all points.

Variable Velocity

Fig. 2 illustrates the motion of a body having a variable velocity. It can be seen that in the first hour the distance covered is 20 miles, whereas in the second hour the distance is 40 miles. Obviously there has been an increase in the velocity. Again, in the 5th hour the distance travelled is only 10 miles and so the velocity has decreased. In such cases it is necessary to determine an instantaneous velocity, or a distance covered in a smaller unit of time during which it can be assumed to be uniform. Since, from previous reasoning, the velocity is the slope of the curve, so, at a point, say X, the slope is found by drawing a line just touching the curve at the point X. This line AB is called the tangent to the curve at X, and the instantaneous velocity is once more given by the ratio $\frac{BC}{AC}$ which is also the tangent of the angle α_1.

Similarly, the tangent at a point Y gives the instantaneous value of the velocity and is equal to the ratio of $\frac{DE}{OE}$ and is described as the tangent of the angle α_2. It can be seen that α_1 is greater than α_2 and therefore the instantaneous value at X is greater than at Y, or where the curve is rising the slope is increasing and the velocity is increasing and where the curve is flattening out the slope is decreasing and the velocity is decreasing.

Acceleration

This brings out a new idea of the rate at which the velocity is changing and introduces a new term, *Acceleration*. Acceleration is defined as the *rate of change of velocity* and may be positive, if the velocity is increasing, or may be negative—sometimes called a deceleration—when the velocity is decreasing. Suppose, for example, that a car has at the end of one second an instantaneous velocity of 10 feet per second and at the end of the next second an instantaneous velocity of 20 feet per second. It follows that the car has gained a velocity of 10 feet per second in one second. If this continues uniformly, then the car possesses a positive acceleration of 10 feet per second every second. This may be written:

10 (feet per second) (per second)
or: 10 feet per sec.^{2}

The first bracket is referring to the *gain* in velocity, the second bracket to the *time* in which the gain takes place.

It is necessary in stating an acceleration to give the change in velocity and also the time of the change, so that the car will be accelerating, say,

100 feet per sec. (per 10 seconds)
or, 50 feet per sec. (per 5 seconds)
or, 10 feet per sec. (per second).

This may be expressed in symbols as follows:

If u is the initial velocity when a series of observations are taken, i.e. the time was zero
If v is the final velocity at the end of an observed time
If t is the observed time, then by definition:

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time of change}}$$

$$\text{or,} \quad a = \frac{v-u}{t}$$

If the initial velocity was zero, that is, $u = 0$, that is to say, that the body was at rest when the first observation was made, then,

$$a = \frac{v}{t}$$

from which it follows that $at = v$.

In the simple cases of uniform acceleration large intervals of time may be taken, but when the acceleration is variable then a small increment of time must be taken, during which the acceleration is assumed to be uniform. This, again, can be illustrated by means of a graph.

Fig. 3 shows velocity plotted vertically, in feet per second, and time horizontally in seconds. Here it can be seen that a body starting from rest has a velocity of 2 feet per second at the end of the first second, 4 feet per second at the end of the second second, and so on throughout the period of time selected for study of the moving body.

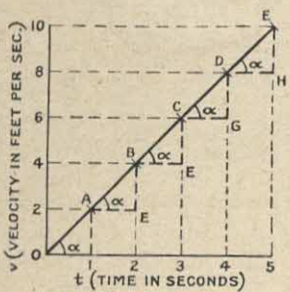


Fig. 3. Velocity-time graph showing acceleration of a body whose speed increases by 2 ft. each second. If acceleration is variable smaller time intervals are taken. Deceleration is treated similarly.

So that from O to A the *change* in velocity is 2—0; equals 2 feet per second and the *time* of change is 1 second and so the acceleration is

$$\frac{\text{Change in velocity}}{\text{Time of change}} = \frac{2}{1} = 2 \text{ feet per sec.}^2$$

represented by the ratio $\frac{\text{A1}}{\text{O1}}$

Similarly from A to B,

$$\frac{\text{Change in velocity}}{\text{Time of change}} = \frac{4-2}{1} = 2 \text{ feet per sec.}^2$$

represented by the ratio $\frac{\text{BE}}{\text{AE}}$

But $\frac{\text{BE}}{\text{AE}} = \frac{\text{A1}}{\text{O1}}$ = the tangent of the slope of the line OD. So that the slope of the Velocity-Time graph is the acceleration.

Further, since the distance travelled from rest, as previously explained, is the product of v and t, that is, $s = vt$, it follows that the area under the curve OD represents the distance travelled.

$$\text{The area under OD} = \text{Average height} \times \text{Time}$$
$$= \frac{\text{Final velocity}}{2} \times \text{time}$$
$$= \frac{v}{2} \times t = \frac{8}{2} \times 4 = 16 \text{ feet.}$$

All these results can now be written down in a tabulated form for convenient reference.

Using the same symbols as before:

From rest $\quad s = \frac{v}{2} \times t$ .... Equation (1)

$v = at$ .... Equation (2)

and substituting in (1)

$s = \frac{1}{2}at^2$ .... Equation (3)

from (2) $\quad t = \frac{v}{a}$

and $\quad s = \frac{1}{2}a\frac{v^2}{a^2}$

$\therefore s = \frac{\frac{1}{2}v^2}{a}$

or, $\quad 2as = v^2$ .... Equation (4)

From initial velocity u and final velocity v

$$v = u + at$$
$$s = \frac{(u+v)}{2}t$$
$$s = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$
$$a = \frac{v-u}{t}$$

It will be obvious that when the body has a decreasing velocity due to a *deceleration*, then the value of a is written down with a minus or negative sign in front of it.

EXERCISES

To be worked by the student. Answers appear at end of the following Lesson.

(1) Distinguish clearly between Velocity and Speed, and give the usual units used.
Express
(*a*) 90 miles per hour in feet per second
(*b*) 15 knots in feet per minute
(*c*) 360 feet per hour in yards per minute
(*d*) 11 yards per minute in miles per hour.

(2) A station is 300 yards long and a train of 230 yards length approaches at a uniform speed of 25 miles per hour. How long does it take for the train to pass completely through the station?

(3) The earth has a radius of 4,000 miles and rotates upon its axis once every 24 hours. What is the linear speed of a point on the Equator in miles per hour?

(4) A man walks from A to B at 3 miles per hour and returns at 4 miles per hour. What is his average rate for the whole journey?

(5) Define uniform acceleration, and state the usual units.
Express:
(*a*) 600 miles per hour per hour in feet seconds units
(*b*) 6 miles per hour per min. in feet seconds units
(*c*) 10 knots per hour in feet seconds units.

(6) A train increases its velocity uniformly from 25 miles per hour to 50 miles per hour in 15 minutes. What distance is travelled in this time? What time elapsed until its velocity was 30 miles per hour? What was the velocity after 14 minutes?

(7) A body increases its velocity uniformly from 15 feet per second to 25 feet per second, while passing over 100 feet. Find the acceleration.

(8) A body starts from rest and moves with a uniform acceleration of 21 feet per second per second. Calculate the distance travelled in the first, second, and third second, respectively.

(9) A train proceeding at a uniform rate of 1,000 yards per minute is 100 yards behind another which is just starting from rest with a uniform acceleration of 3 feet per second per second. In how many seconds will there be a collision ?

(10) A car travels between two traffic lights 300 yards apart. From being at rest at the first, it accelerates at 4 feet per second per second until it reaches a maximum speed of 30 miles per hour. The second light is showing red and so the car decelerates at 5 feet per second per second until it reaches the signal when it just comes to rest. What time elapsed from stop to stop ?

LESSON 2

Gravity, Angular Velocity, and Kinetics

THE problem of the falling body had long interested the early scientists. Aristotle (384–322 B.C.), a disciple of Plato, and teacher of Alexander, who became Alexander the Great, was probably the most famous of all Greek philosophers. His ideas concerning falling bodies, however, lacked the very necessary experimental verification. He stated that heavy bodies fall to the ground more quickly than light if both are dropped from the same height. He believed, in fact, that a 1 lb. weight would take, say, 10 seconds to reach the earth if a 10 lb. weight dropped from the same height took 1 second. In all fairness to him, the consideration of the restraining influence of the air on the falling body must have escaped him, and he may have compared the rates of fall of a piece of metal, say, the size of a penny, and a piece of thin paper of the same area.

16th-century Experiments

At any rate, this belief persisted until A.D. 1591, when Galileo Galilei demonstrated with a 100-lb. shot and a 1-lb. shot which he dropped together from the top of the famous leaning tower of Pisa. The results of this experiment proved beyond doubt that both reached the ground in practically the same time, the slight difference between them being due to the fact that the air had a more effective resistance to the lighter body.

Galileo's Conclusion

He further argued, if the two bodies were tied together then, because the combined weight was greater than either, they should reach the ground in a shorter space of time; but, the lighter body taking a longer time to reach the ground, it should have a restraining influence on the other so that the two should take longer to reach the earth. Here was an obvious contradiction which needed explanation, and the final conclusion he reached was that all bodies when dropped from the same height reach the ground in the same time, if the resistance of the air could be eliminated.

Later, Sir Isaac Newton performed his guinea and feather experiment, proving conclusively this important fact. In air the feather took a considerably longer time to float down compared with the small, heavy coin; but when these two were enclosed in a long glass tube from which as much air as possible had been exhausted, both articles reached the bottom of the tube from the top in precisely the same time.

Freely Falling Bodies

The fact was that the feather falling through air was resisted by the air itself, so that there were two forces acting upon the body, the one due to the attraction of gravity, the other, acting in the opposite direction, due to the air resistance. This fact holds true for all falling bodies, but the heavier the body the smaller the air resistance. For elementary calculations, however, the falling body is assumed to be " in vacuo " when it is stated to be " falling freely."

Considering such bodies falling freely, it is obvious that starting together from rest and taking the same time to fall the same distance they acquire the same velocity. In fact, they acquire the same increase in velocity for every second of their flight, or, using the motions put forward in Lesson 1, they proceed to the earth with *equal uniform acceleration*.

Acceleration due to Gravity

This acceleration due to gravity, symbolised by the letter g, has a value which is practically constant throughout the world, the slight variation of the value being proportional to the distance of the point of observation from the centre of the earth.

Thus g has a mean value in London of 32·19 feet per second per second or, in centimetre-second units, of 981·19 centimetres per second per second, while at the Equator the value is 32·09 ft./sec.^{2} and 978·63 cms./sec.^{2}, and at the Poles 32·25 ft./sec.^{2} and 983·216 cms./sec.^{2}. Unless otherwise stated, the value for g is taken as 32·2 ft./sec.^{2} or 981 cms./sec.^{2}.

It will be apparent that the same equations of motion derived in Lesson 1 are still applicable, using the symbol g for acceleration and h (height) for distance travelled, the positive or negative value of g being used according to whether the body is proceeding towards or away from the centre of the earth. Thus :

$$v = u + gt$$
$$h = \frac{(u + v)}{2}t$$
$$h = ut + \tfrac{1}{2}gt^2$$
$$v^2 = u^2 + 2gh$$
$$g = \frac{v - u}{t}$$

Angular Velocity

There are many examples in machinery where bodies are rotating about an axis, as, for instance, gear wheels, pulleys, flywheels, and propellers, either at a constant or a variable velocity. In such cases it is sometimes more convenient to discuss the rate at which the body revolves about its axis of rotation rather than the actual linear distance travelled by a particular point on the body.

Since a point on the circumference of such a body traces out a circle of 360 degrees in one complete revolution, it is possible to express its velocity as a number of degrees in a unit of time. For example, consider a point A on the rim of the tyre of a car wheel as shown in Fig. 4. Suppose the wheel completes one revolution in one second of time ; then the angular velocity is expressed by :

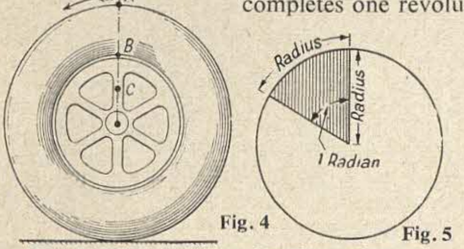


Fig. 4

Fig. 5

Fig. 4 (left). Velocity of moving points on car wheel measured in degrees per sec. Fig. 5 (right). Better expressed in radians per sec.

$$\frac{\text{The angular distance moved through}}{\text{The time taken}} = \frac{360}{1}$$

$= 360$ degrees per sec.

Now consider points such as B and C; these also complete one revolution in one second and therefore have the same angular velocity, so that the advantage of such a measurement is at once apparent since all points on the wheel have the same angular velocity although their linear velocities are quite different.

It is more convenient in most engineering problems to use as an angular measure the radian. *A radian is that angle subtended by a length of circumference equal to the radius.*

Thus, if the radius of a circle is R, the circumference is 2πR and, from the definition given, there are $\frac{2\pi R}{R} = 2\pi$ radians in one complete circle. It also follows that as 2π radians equals 360 degrees there are $\frac{360}{2\pi} = 57{\cdot}3$ degrees to one radian. (For π *see* MATHEMATICS.)

Angular velocity expressed in radians per second is usually denoted by the Greek symbol ω (omega). To convert from angular velocity to lineal velocity, multiply by the radius; conversely, to convert from lineal to angular velocity, divide by the radius.

This is expressed in mathematical terms as :

$$\omega R = v \qquad \text{or} \qquad \omega = \frac{v}{R}$$

Equations of Angular Motion.

Using the symbols :

ω_1 = initial angular velocity
ω_2 = final angular velocity
α = total angle (radians) turned in time t
θ = (Greek symbol Theta) angular acceleration, i.e. change in angular velocity per unit time.

$$\omega_2 - \omega_1 = \theta t \quad \ldots\ldots\ldots\ldots\ldots \text{ Equation (1)}$$

$$\alpha = \frac{\omega_1 + \omega_2}{2}t \quad \ldots\ldots\ldots\ldots\ldots \text{ Equation (2)}$$

From (1) and (2)

$$\alpha = \omega_1 t + \tfrac{1}{2}\theta t^2 \quad \ldots\ldots\ldots\ldots \text{ Equation (3)}$$

Also $\quad t = \frac{\omega_2 - \omega_1}{\theta}$

Inserting this in (2)

$$\omega_2^2 - \omega_1^2 = 2\theta\alpha \quad \ldots\ldots\ldots\ldots \text{ Equation (4)}$$

The student should compare these equations with those given in Lesson 1.

Harmonic Motion

It is beyond the scope of this Course to deal mathematically with the problems involving *simple harmonic motion* (S.H.M.), but it is as well at this point to give a definition of the term. Simple harmonic motion takes place when a body is oscillating in such a manner that its acceleration is directly proportional to its distance from its mean position.

For example, imagine a child's hoop upon which a large bead has been fastened. This hoop is revolving about an imaginary axis at its geometric centre. A strong light is thrown on to the hoop from immediately above, so that a shadow is projected on to the ground below. The shadow of the hoop appears as a straight line, the bead

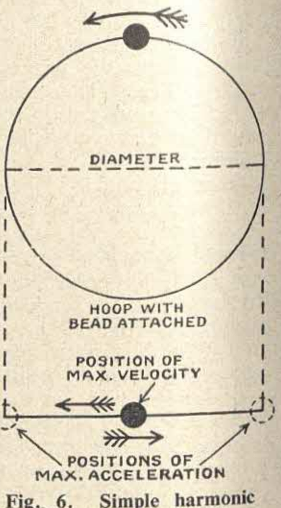


Fig. 6. Simple harmonic motion can be studied from a bead on a child's hoop.

on it as a black spot. As the hoop revolves, the black spot moves to and fro along the line executing simple harmonic motion, having an acceleration directly proportional to its distance from the *mean* position, which is the centre of the line.

It can be shown that the bead reaches a maximum velocity at the centre of its travel and a maximum acceleration at the extreme ends of its movement. In other words the bead, revolving with the ring at a constant angular velocity in a circular path, has a variable lineal velocity and acceleration. This is illustrated in Fig. 6 (a further discussion of this subject appears in the Course on PHYSICS).

Having investigated motion from the purely abstract or " kinematical " point of view, it is now necessary to consider what moves, and what causes it to move.

Newton, as mentioned in Lesson 1, developed the ideas of Galileo and set them down as three basic Laws. The first point that occurred to him was the fact that a body remains at rest or in a state of *uniform* motion in a straight line, unless acted upon by an impressed force. This first Law is often referred to as the *Law of Inertia*, which virtually states that :

A body continues in its state of rest or at a uniform velocity in a straight line unless it is compelled to do otherwise by an external force or forces.

The first part of the Law is a truism, and examples of this property of inertia will occur to the reader. The person standing in a carriage of a stationary train will be jerked off his balance if the train starts suddenly. The reason is that the force which produced motion in the train was not applied to the traveller except at the soles of his feet, and thus the natural tendency of the body to remain at rest exerted itself, and although the soles of the feet were urged forward the body as a whole remained behind.

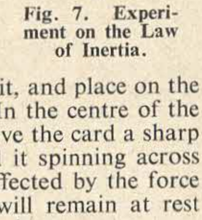


Fig. 7. Experiment on the Law of Inertia.

A simple experiment (Fig. 7) illustrates this. Take a glass tumbler, invert it, and place on the top an ordinary postcard. In the centre of the card place a penny. Now give the card a sharp flick with the finger to send it spinning across the room. The penny, unaffected by the force which propelled the card, will remain at rest on the top of the inverted glass.

It is not so easy to satisfy oneself on the second part of the Law, although it is certain that if the traveller in the train was still standing while it was travelling at high speed he would lose his balance in a forward direction if the train came to rest abruptly. This time the traveller is unaffected by the force which must be applied to bring the train to rest, except (as before) through the soles of his feet, and apparently he would continue forward at the original speed of the train.

The real importance of this Law lies in the suggestion of a definition of " force " inasmuch as a FORCE is that which produces, or tends to produce, motion.

The second law states that :

The rate of change of the quantity of motion in a body is proportional to the impressed force and takes place in the direction of the impressed force.

Here Newton provides a precise definition of " force." The quantity of motion in a body is the product of the mass of the body and its instantaneous velocity, and the modern term for this is *momentum.*

Thus, momentum $= m \times v$, and since the force (F) is proportional to the rate of change of momentum and the mass of the body does not change, it follows that the law can be expressed thus :

Force (F) is proportional to the product of the mass (m) and the rate of change of velocity (v). But the rate of change of velocity has been defined as the acceleration (a) thus :

$$F \text{ is proportional to } m \times a$$

or, $F = k \times m \times a$ where k is a constant which can be evaluated as soon as a unit of force has been decided upon.

Actually the unit of force has been defined as :

that force which, when acting upon a unit mass, produces an acceleration of one unit per second per second.

Thus the constant becomes equal to unity, and thus the fundamental equation can now be written :

$$F = m \times a$$

Using British measurements (i.e. foot, pound, second, units), this unit force is called a *poundal* and it produces in a one-pound mass an acceleration of one foot per second per second.

Using the C.G.S. system of units (i.e. centimetre, gramme, second units), this unit of force is called a *dyne* and it produces in a mass of one gramme an acceleration of one centimetre per second per second.

Newton's third Law states that :

To every action there is an equal and opposite reaction.

This fact can be readily appreciated when considering static bodies. For example, a book resting on a table is exerting a force, due to its weight, upon the table, which in turn is exerting an upward thrust exactly equal and opposite, so that the book remains at rest : also, it is quite impossible to exert a pull on a rope unless the other end of the rope is fastened in such a way that it can resist the pull by an exactly equal and opposite amount. This can be simply demonstrated by means of two spring balances. Attach one to each end of a rope. Hook one of the balances on to a staple fastened into a wall, and exert a pull on to the other balance. The amount of pull exerted on the spring balance in the hand is precisely the same as the amount recorded on the balance attached to the staple. In other words, the staple is resisting the pull by an equal and opposite amount. Incidentally, if the rope was cut and a third balance inserted between the other two it also would be recording the same pull.

The principle goes farther and is equally true when the bodies are in motion. Imagine a trailer attached to a motor lorry by means of a stiff spring. When the lorry begins to move forward, the trailer, owing to its inertia, remains at rest and the spring begins to extend. When finally the pull in the spring is just sufficient to overcome the inertia of the trailer, it too will begin to move forward, and when the two are thus in motion at any instant the spring will be exerting the same pull backwards on the motor lorry as it exerts forwards on to the trailer.

EXERCISES

Answers appear at the end of the following Lesson. Take g to be 32·2 feet per sec. per sec.

(1) Calculate the distances traversed in feet, and the velocities acquired in feet per second, by a body falling freely from rest for (*a*) 5 seconds, (*b*) ½ second.

(2) Calculate the maximum velocity reached and the time taken, in each case, when a body falls freely from rest through (*a*) 600 feet, (*b*) 1,000 yards, (*c*) 12 inches.

(3) A body is falling freely under the action of gravity. What distance does it cover in the third and also in the seventh second of its flight ?

(4) A cricket ball is thrown vertically up into the air and it returns to the hand in 6 seconds. With what initial velocity did the ball leave the hand, and what maximum height did it reach ?

(5) A lift is rising at a uniform rate of 4 feet per second when a passenger drops his walking stick through the gates. The stick reaches the ground in 2 seconds. At what height was the lift from the ground when the stick was released ?

(6) An anti-aircraft shell fired vertically upwards reaches a height of 15,000 ft. What was the initial muzzle velocity?

(7) A mass of 1 lb. moves from rest with an acceleration of 5 feet per second per second. Calculate its momentum after 10 seconds.

(8) A force of 30 poundals acts on a mass of 10 lb. Calculate the time taken to describe 100 feet from rest, and the space moved through in the 4th second of its motion.

(9) The wheels of a motor car are 27 inches outside diameter. The car is running along a road at 30 miles per hour. Assuming no slip between the road and the wheels, calculate the speed of the wheels in radians per second and revolutions per minute.

ANSWERS TO EXERCISES IN LESSON 1

(1) (*a*) 132 feet per sec., (*b*) 1,521 feet per minute, (*c*) 2 yards per min., (*d*) 0·375 miles per hour.
(2) 43·37 seconds.
(3) 1,048 miles per hour.
(4) $3\frac{3}{7}$ miles per hour.
(5) (*a*) 0·2445 ft./sec.^{2}, (*b*) 0·1467 ft./sec.^{2}, (*c*) 0·004691 ft./sec.^{2}
(6) 9·38 miles; 3 minutes; 48·33 miles per hour.
(7) 2 ft./sec.^{2}
(8) 10·5 feet; 31·5 feet; 52·5 feet.
(9) 7·84 seconds.
(10) 30·35 seconds.

LESSON 3

Mass and Composition of Velocities

THE subtle distinction between the two terms Mass and Weight has unfortunately caused much confusion among students ; but, except that the choice of one or the other influences the *unit of force* employed, this difference should not be regarded as fundamentally important. Sir Isaac Newton rather vaguely defined the " mass " of a body as being the quantity of matter in it, and showed that the force necessary to overcome its inertia was proportional to this mass. His fundamental equation, $F = m \times a$, indicates that the greater the mass the greater the force to produce the same acceleration.

In other words, a hollow celluloid ball, having a small mass, would require less force to produce an acceleration of, say, 10 ft. per sec. per sec. than a ball of lead of the same dimensions, having of course a larger mass.

The mass is measured on a pair of ordinary scales against some specific standard. The British unit of mass is actually a piece of platinum which is preserved in London and measures 1 pound avoirdupois (1 lb.). If this unit of mass is suspended on a spring balance it immediately comes under the influence of the attraction of the earth, so that what is really being measured is the force with which the 1-pound mass is being pulled towards the earth by the action of gravity.

Absolute Units of Force

If this mass of 1 lb. were released from the balance it would accelerate towards the centre of the earth under the influence of the 1 lb. force. As shown in Lesson 2, this acceleration would be 32·2 ft./sec.^{2}, therefore it follows that a force of $\frac{1}{32\cdot2}$ lb. will cause an acceleration of 1 ft./sec.^{2}.

In the British system the force required to produce an acceleration of 1 ft./sec.^{2} on a mass of 1 lb. is termed the *poundal* and is equal to $1/g$ lb. ($\frac{1}{32\cdot2}$ lb. or approximately ½ oz.). The absolute unit of force in the metric system is

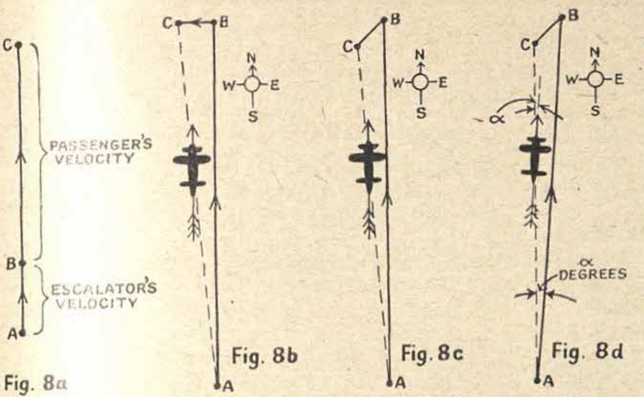


Fig. 8a Fig. 8b Fig. 8c Fig. 8d

COMPOSITION OF VELOCITIES. Velocities expressed by straight lines (vector quantities). Fig. 8a. Sense and combined velocity of passenger mounting escalator. Figs. 8b-8d. Velocities to scale of an aeroplane flying against different winds.

the *dyne* which is equal to $\frac{1}{981}$ grams. Thus:

$$F \text{ (absolute units)} = M \text{ (gravitational units)} \times a$$

or

$$W \text{ (gravitational units)} = \frac{M \text{ (gravitational units)} \times a}{g}$$

e.g.

$$W \text{ (lbs.)} = \frac{M \text{ (lbs.)} \times a \text{ (ft./sec.}^2\text{)}}{32{\cdot}2}$$

or

$$W \text{ (grams)} = \frac{M \text{ (grams)} \times a \text{ (cm./sec.}^2\text{)}}{981}$$

In solving problems, therefore, it is quite clearly necessary to specify at each step the units employed. For example, if a crate weighing 100 lb. is being lifted from a ship's hold by means of a wire rope attached to a winch, then if the crate is rising at a *uniform* rate the force exerted in the wire is 100 *lb. weight.*

This is the dead weight of the crate downwards. If the winch speeds up and causes the crate to accelerate upwards at 4 ft. per sec. per sec., then the additional force in the wire rope giving this acceleration is calculated from:

$$W = \frac{m \times a}{g} = \text{lb. load due to acceleration.}$$

$$W = \frac{100 \times 4}{32{\cdot}2} = 12{\cdot}4 \text{ lb.}$$

herefore the total force in the rope is now

$$\text{dead weight} + \text{load due to acceleration}$$

$$= 100 + 12{\cdot}4 = 112{\cdot}4 \text{ lb.}$$

It has previously been emphasised that a velocity is a rate of change of position in a *specified direction*, and therefore it can be graphically represented by a straight line drawn to some convenient velocity scale. This straight line must give

(*a*) The magnitude of the velocity

(*b*) The direction of the velocity, and

(*c*) The sense (indicated by an arrow head drawn on the line).

Because velocity can thus be described graphically it is known as a *vector quantity*.

The idea of expressing a velocity as a straight line becomes extremely useful when considering bodies which may be under the influence of two independent velocities simultaneously. A simple example occurs in the moving stairway, or escalator. Suppose an escalator is moving at 2 ft. per sec. uniformly, and carries passengers from an underground railway to the surface. If a traveller stands still on one stair (he is only still relative to the stair), then he is lifted upwards a distance of 2 ft. every second. This uniform velocity is represented in Fig. 8a by a straight line AB, which measures to a suitable scale 2 ft. per second; the *direction* is indicated by the position of the line, the *sense* by the small arrow head on the line (upwards).

If the traveller suddenly decides to begin to walk up the stairs at a uniform pace of 6 ft. per second (relative to the stairs), this can be represented by the continuation of AB to BC in the same direction and with the same sense and to the same scale. He is now under the influence of two distinct and independent velocities—the stairway at 2 ft./sec. and his own locomotion of 6 ft./sec. It follows therefore that in one second he has moved altogether 2 + 6 ft. = 8 ft.: in other words, the vector quantity AC. This means that his velocity of ascent is now 8 ft. per second, which is the *vector addition* of AB and BC and is the measured distance AC to scale in Fig. 8a.

Again, suppose an aeroplane is flying due north at 440 ft. per second and a wind is blowing at 44 ft. per sec. from east to west. In Fig. 8b AB represents the aeroplane's velocity in magnitude, direction, and sense, if the engine was the sole propellant. If the wind was acting alone, then BC represents its velocity *to the same scale*. It follows that, if both velocities are acting together then AC is the vector addition and if measured will give the true velocity of the aeroplane—often referred to as the true ground speed—and the direction is given by the angle of the line, the sense by the arrowhead on the line

If the wind is blowing from the north-east, then Fig. 8c shows the vector addition AC, again in magnitude, direction, and sense. It will be noticed that the aeroplane is moving "crabwise" over the landscape. One of the problems of the pilot is to correct this drift by changing his course from due N. so that his actual direction AC carries his aeroplane the way he wishes to go. If the aeroplane is to travel due N. the pilot steers an amount α degrees east of north, so that the vector addition of the aeroplane and wind speeds has a true N. bearing, as shown in Fig. 8d.

When a train is running along a track and an aeroplane is flying obliquely across the track, then the *observed* velocity and direction of the train to the pilot is not the true ground conditions but a *relative* velocity of the train to the aeroplane. Similarly, a passenger in the train watching the aeroplane observes only the relative velocity of the plane to the train. In both cases the observer imagines that his own velocity is zero—and so it is of course *relative* to the vehicle in which he is sitting.

To clarify these conditions it is easier to refer both moving bodies to a third which can be considered stationary. It is common to think of the earth as having no velocity.

The problem is simplified by following a few elementary rules, probably best illustrated by a concrete example. In Fig 9a the aeroplane A is flying from N.E. to S.W., indicated by the feathered arrow, at 300 miles per hour or 440 ft. per second. The compass points shown on the diagram are fixed to the earth, which is assumed stationary, so that the vector quantity Aa in Fig. 9a drawn to some convenient scale gives the velocity of the plane relative to a fixed earth in magnitude, direction, and sense. This is the *absolute* velocity of the plane.

Similarly, in Fig. 9a, the train B is travelling due east at 60 miles per hour or 88 ft. per second, and this is illustrated by the vector line Bc drawn to the same scale in Fig. 9b. This is the absolute velocity of the train.

Now fix one of the moving bodies relative to the earth by applying an equal and opposite velocity. For instance, stop A by applying the velocity Ab (shown dotted). This same velocity which has stopped A must now be also applied to B, and now B is under the influence of two velocities, viz. Bc representing 88 ft./sec., and Bd representing 440 ft./sec. (shown in Fig. 9b). Complete the parallelogram BdCc, and the diagonal BC represents the vector addition of Bc and Bd and also it represents the velocity of B relative to A which is now a fixed point on the earth. This means that the pilot *observes* the train to be proceeding at a speed of BC in a direction α to the compass direction due east.

This result can be checked by now considering the train B stopped by applying an equal and opposite velocity Be and now B is stationary relative to the earth. Apply this velocity to A, which will now be under the influence of two velocities, viz. its own and the imposed Af (Fig. 9c) equal to Be. Once more complete the parallelogram of velocities and draw in the diagonal AE, and now AE is the velocity of A relative to B. To scale, this is exactly the same magnitude and direction but the *sense* is reversed as indicated by the arrow on the line.

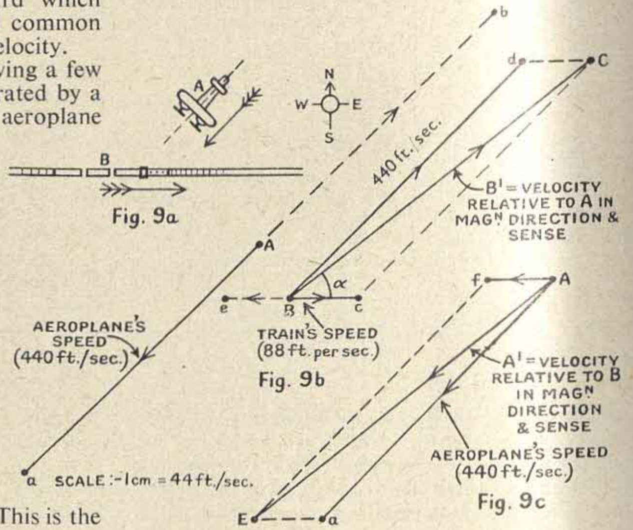
EXERCISES

Answers appear at the end of the following Lesson.

Take g to be 32·2 ft. per sec. per sec.

(1) A golf club is swung so that it produces a force equal to a weight of 5 lb. on a golf ball, which accelerates from the tee at 161 ft. per sec. per sec. What is the mass of the ball ?

(2) A porter weighing 140 lb. is descending in a lift which is accelerating at $\frac{1}{4}g$ ft. per sec. per sec. What force does he exert on the floor of the lift ? What is the force when the lift is descending at g ft./sec./sec. ?


b
d
C
N
W
E
S
A
B
440 ft./sec.
B¹ = VELOCITY RELATIVE TO A IN MAGN. DIRECTION & SENSE
Fig. 9a
A
α
e
B
c
AEROPLANE'S SPEED (440 ft./sec.)
TRAIN'S SPEED (88 ft. per sec.)
Fig. 9b
f
A
A¹ = VELOCITY RELATIVE TO B IN MAGN. DIRECTION & SENSE
AEROPLANE'S SPEED (440 ft./sec.)
Fig. 9c
a
SCALE :- 1cm = 44 ft./sec.
E
a

RELATIVE VELOCITIES. Figs. 9a–9c. Plotting to scale, by vector additions, absolute and relative velocities of an aeroplane and a train, giving sense and direction.

(3) A dart weighing 2 oz. is flung at a dartboard at 12 ft. per second and penetrates the board ½ inch. Find the mean resistance of the target.

(4) A ship steams due north at 10 knots and an officer on watch walks across the bridge, from starboard to port, at 3 miles per hour. What is the officer's actual speed and direction ?

(5) A rowing boat is propelled across a river so that its speed in still water would be 4 miles per hour. The river is flowing at 4 miles per hour. In what direction must the boat steer so that it travels across the stream at right angles to the banks ?

(6) Two travellers part at a cross-roads. One walks due east at 3 miles per hour, the other walks due south at 4 miles per hour. How far are they apart at the end of 2 minutes ?

(7) To an observer on a train travelling due west at 30 miles per hour, an aeroplane appears to be travelling due south at 100 miles per hour. What is the true course and speed of the aeroplane ?

ANSWERS TO EXERCISES IN LESSON 2

(1) (*a*) 402·5 feet ; 161·0 ft./sec. (*b*) 4·03 feet ; 16·1 ft./sec.
(2) (*a*) 196·6 ft./sec. ; 6·105 secs. (*b*) 439·5 ft./sec. ; 13·65 secs. (*c*) 8·025 ft./sec. ; 0·2492 secs.
(3) (*a*) 80·5 feet ; (*b*) 209·5 feet.
(4) 96·6 ft./sec. ; 144·9 feet.
(5) 56·4 feet. (6) 982·9 ft./sec.
(7) 50 ft. lb. sec. units. (8) 8·15 secs. ; 10·5 feet.
(9) 39·1 radians/sec. ; 374 revolutions/minute.

LESSON 4

The Principles of Statics

As defined in Lesson 1, this branch of Mechanics concerns itself with forces acting on a body which is at rest. Under such conditions the forces produce *balance* or, in scientific language, a *state of static equilibrium.* Any number of forces may act simultaneously upon a body, each, if acting separately, capable of producing an acceleration. But these forces can be so disposed round the body that their net effect is zero and the body remains at rest. Statically these forces are measured in terms of the weight they can support.

Examples of Static Equilibrium

A simple example occurs in the tug-of-war, where two teams exert forces in opposite directions. The indicating ribbon, at the centre of the rope, remains at rest when the two teams are exerting equal and opposite forces on the rope, and the system is in static equilibrium. If one side makes an additional exertion, then this extra force will produce motion in its own direction.

When a book is dropped on to a table the only force acting upon it, to start with, is that due to gravity, which will, if not interfered with, produce an acceleration towards the earth. At the instant that the book comes into contact with the table the motion is destroyed ; but the force is still continuing to act, and is resisted by an equal and opposite upward pressure on the part of the table which prevents further downward motion. This passive resistance on the part of the table is called the *reaction* and is equal and opposite to the attraction of gravity.

Dynamically, two forces are considered to be equal if, when applied separately to the same body for *equal* intervals of time, they tend to produce the same change of velocity.

Statically, however, forces are equal if when applied to a body simultaneously in diametrically opposite directions the body remains at rest.

It can be seen that these forces producing equilibrium do not depend upon the mass of the body upon which they act, but only upon the forces themselves. The static unit of force, in British measurement, is the weight of one pound and is simply called " the force of one pound." Since such forces have specific directions they are vector quantities, and may be graphically represented by straight lines. Completely to define such a force it is necessary to state :

(1) Its point of application on the body ;
(2) Its direction ;
(3) Its sense, whether a push or pull ;
(4) Its magnitude, so many lb. wt. drawn to convenient scale.

Forces in the Same Straight Line

Fig. 10 shows a spring balance from which is suspended a weight, W lb. It is clear that the hook must be exerting, on the weight, a force equal and opposite in direction to that which is exerted by the weight.

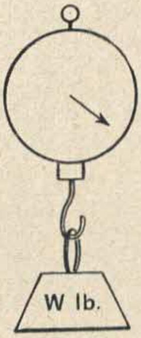


Fig. 10

If several forces all in the same straight line act on a point, the point will be in equilibrium if the sum of the forces acting in one direction equals the sum of these forces acting in the opposite direction. Thus, considering the forces in Fig. 11 (above) P_1, P_2, P_3, P_4 and P_5

$$P_1 + P_2 + P_3 = P_4 + P_5$$

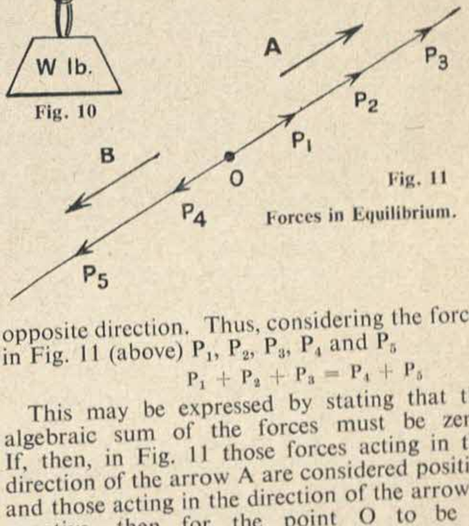


Fig. 11 Forces in Equilibrium.

This may be expressed by stating that the algebraic sum of the forces must be zero. If, then, in Fig. 11 those forces acting in the direction of the arrow A are considered positive and those acting in the direction of the arrow B negative, then for the point O to be in equilibrium

$$P_1 + P_2 + P_3 - P_4 - P_5 = O$$

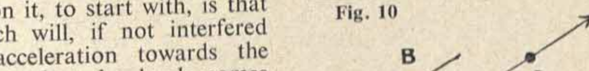


Fig. 12. Resultant and Equilibrant.

Consider now the point O in Fig. 12. It is under the influence of the three loads—P_1, P_2 and P_3—and cannot therefore be in equilibrium.

The force required to balance the system is called the *Equilibrant* and it is shown by the dotted line and arrow E. P_1, P_2 and P_3

can be replaced by a single force which is termed the *Resultant.*

$$P_1 + P_2 + P_3 - E = O$$
$$\text{and as } P_1 + P_2 + P_3 = R$$

the Resultant (R) must be equal and opposite in sense to the Equilibrant (E).

Intersecting Forces

A force is a vector quantity because it can be represented by a straight line, the angle of the line representing direction, and the length, to a suitable scale, representing magnitude. Fig. 13a shows three forces acting on a point O.

Suppose two forces, A and B (Fig. 13a), are acting on a point O and it is required to find the force E required to maintain the system in equilibrium. To determine the Equilibrant E the following construction is used. Set off (Fig. 13b) in the direction in which A acts, a line the length of which represents, to a suitable scale, the magnitude of the force, and mark on the direction of the force. Next, the load B to the same scale and in the direction of the load. The Equilibrant is fully described in direction and magnitude by the line that closes the *Triangle of Forces.*

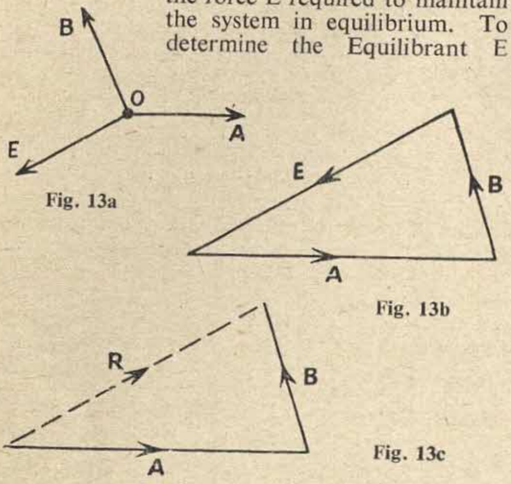


Fig. 13a

Fig. 13b

Fig. 13c

TRIANGLE OF FORCES

Note: (a) For equilibrium the triangle must close.

(b) Each force must be taken in turn; anticlockwise is usual, but the result is not affected if the forces are taken in clockwise order.

(c) The arrows indicating the direction of the forces must follow round the triangle.

Fig. 13c shows the same triangle but it has been closed with the dotted line R. R is the Resultant of A and B and it is equal but opposite in sense to the Equilibrant E.

It can also be argued that if any number of forces acts through a common point in the same plane (referred to as *co-planar forces*) and such a system is in equilibrium, then a polygon of forces can be drawn which is a closed figure and the sides of which taken in order will represent the magnitude, to some scale, and the direction of each of the forces. Thus, a graphical solution is obtained from which the magnitude of the forces can be measured directly, and the directions indicated by the slopes of the lines, and the senses of the forces shown by the arrow heads placed on the lines. Generally speaking, the graphical solution to such problems involving static equilibrium is the simplest.

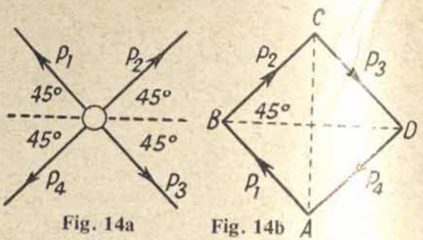


Fig. 14a Fig. 14b

POLYGON OF FORCES. Fig. 14a. System of co-planar forces in equilibrium. Fig. 14b. Polygon showing magnitude, direction and senses of forces in Fig. 14a.

Suppose that 4 ropes are attached to an iron ring, as shown in Fig. 14a, and take loads of P_1, P_2, P_3, P_4 respectively. Each rope is inclined at 45 degrees to the horizontal. Then proceeding round the system in order beginning with P_1 the polygon ABCD can be drawn (Fig. 14b). AB is drawn parallel to P_1 and of length equal to P_1 to some scale and similarly for the other three forces.

Now if the system is in equilibrium, i.e. the iron ring is at rest, then the figure ABCD is a closed polygon, and by considering the geometry of it, it follows that all the four forces are equal to one another.

Applying Force Diagrams

Suppose now that forces P_2 and P_3 are inclined at 30 degrees to the horizontal, while P_1 and P_4 remain at 45 degrees, as shown in Fig. 15a. The polygon now assumes the shape EFGH as shown in Fig. 15b, and once more if the system is in equilibrium the figure closes and the magnitude of each of the forces can be directly scaled from the diagram. Again in this simple case it is obvious that the figure

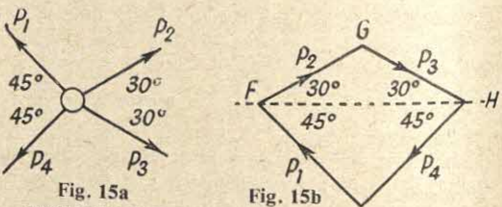


Fig. 15a Fig. 15b

FORCE DIAGRAM. Example of applying the Polygon of Forces (Fig. 15b) to a Force System (Fig. 15a).

is symmetrical and that P_2 is equal to P_3 and P_1 is equal to P_4.

To take a further example, suppose that a tree is pulled in four directions, north, east, south, and west simultaneously, by forces producing tensions in four ropes of 20, 40, 60 and 80 lb. respectively, as shown in Fig. 16a. Choosing a convenient scale of, say, 20 lb. to the inch, draw the polygon *a b c d e* going round the system in order. It will be noticed that the polygon does not close because *e* does not coincide with *a* (Fig. 16b). Therefore, from what has been said previously, such a system of forces is not in equilibrium. Join *e* to *a* so that the figure closes completely, and it is apparent that the force *e a* in magnitude and direction is the one which must be applied to the tree to produce static equilibrium. Actually, of course, without this force *e a* the roots would have to supply the same value, or, failing to do so, the tree would be pulled bodily from the ground in the direction of *a* to *e*. So that the force *a e* (in the direction of *a* to *e*) is the resultant of the four existing forces, and *e a* (in the direction of *e* to *a*) is the equilibrant. This equilibrant may be scaled directly from the diagram: *e a* equals $\sqrt{2} \times 40$ equals 56·56 lb. and the angle θ equals 45 degrees. Note that the arrow heads indicating the senses of each force "chase" one another round the diagram, so that there should be no confusion as to the direction of the equilibrant and the resultant. If this force of 56·56 lb. is applied to the tree in the direction north-east, then under the influence of the five loads the tree is in static equilibrium.

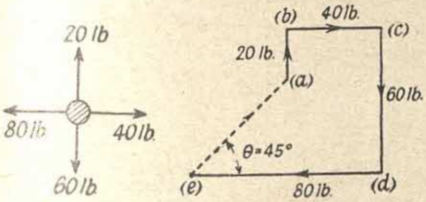


Fig. 16a Fig. 16b

Applying the Polygon of Forces to a Force System that is not in equilibrium.

Suppose a steel shaft 20 ft. long is to be lifted by a chain. One method of doing this is shown in Fig. 17, where a chain is attached from each end to a central ring through which the crane hook passes. The crane hook applies a vertical pull upwards equal to the dead weight of the shaft which is acting under the attraction of gravity downwards. Here is a case of three forces acting through a common point, the ring centre R upwards equal to the weight of the shaft and T_1 and T_2 equal to the tensions in each of the two chains. When the shaft is suspended off the ground the system is in equilibrium. If the chains are short and in consequence the angle α is small, it can be seen from the triangle of forces drawn to scale in Fig. 18 that the magnitudes of the forces T_1 and T_2 are very big; in fact, they can be so big as to cause the links to fail.

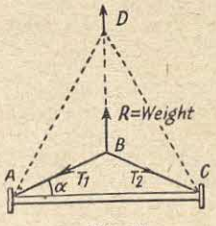


Fig. 17

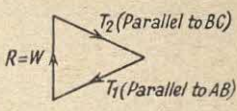


Fig. 18

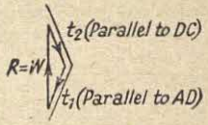


Fig. 19

APPLICATION IN PRACTICE. Fig. 17. Sling lifting a shaft, three forces acting through common points. Figs. 18 and 19. Triangles of forces showing the effect of slings of different length.

On the other hand, if the chains are long and angle α is large, as shown by the dotted lines, the tensions t_1 and t_2 are correspondingly smaller; better arrange for the slings to be vertical, when angle α is 90 degrees, in which case each chain would take the least possible tension, equal to half the weight of the shaft.

It has been explained that if two forces are acting at a common point they may be replaced by a *resultant force* which will have exactly the same effect upon the body, and that this resultant can be obtained graphically by drawing in the diagonal of the parallelogram of forces. It is obvious therefore that, conversely, given a single force acting at a point, this force can be *resolved* into any two directions by simply considering this force as the diagonal of a parallelogram. The two sides of the parallelogram give the two forces acting at the common point which together will have the same effect upon the body as the previous single one. These resolved forces are *components* of the original and may be taken in any two selected directions.

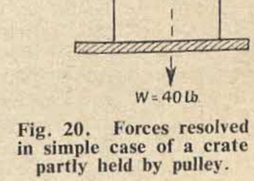


Fig. 20. Forces resolved in simple case of a crate partly held by pulley.

It is a common practice to take the components at right angles to one another, although this choice is quite arbitrary. In Fig. 20 a crate weighing 40 lb. is resting upon the platform of a weighing machine. A rope is attached to the top, passed through a pulley in an overhead beam, and a force of 20 lb. is applied. The pulley is arranged so that the pull is in a direction at 30 degrees to the vertical. This force of 20 lb. can be resolved vertically and horizontally.

The vertical component of the force is 20 cos 30 = 20 × 0·866 = 17·32 lb.

The horizontal component is 20 sin 30 = 20 × 0·5 = 10 lb.

This result can also be obtained graphically by marking off along the rope to a convenient scale of force a distance representing 20 lb., and then completing the parallelogram ABCD of which the diagonal is AC and equals 20 lb.; the two components AD and AB can be scaled off directly. This should be verified by the student.

The vertical force of 17·32 lb. upwards will act against the 40 lb. weight acting downwards and tend to lift the crate from the weighing platform and thus the machine will now register 40 — 17·32 = 22·68 lb. weight. The horizontal force of 10 lb. will tend to slide the crate to the left. Since the *normal* reaction between the crate and the platform is now 22·68 lb., then (unless the coefficient of friction between the two surfaces is greater than 0·441) the box will begin to move to the left because

$$\frac{10}{22{\cdot}68} = \mu \text{ (the coefficient of friction) } = 0{\cdot}441.$$

Further examples of the resolution of forces are given here for the student to work out.

EXERCISES

(1) Two forces acting together in the same straight line have a resultant of 20 lb. and when these act in opposite directions their resultant is 4 lb. Find the two forces.

(2) A picture 2 ft. square weighs 24 lb. and is supported by a cord 4 ft. long attached at its ends to the top two corners of the frame and passing round a hook on a picture rail. What is the resultant force on the rail and the tensions in each of the two parts of the cord if the top edge of the picture is horizontal?

(3) Two chains are attached to an eyebolt in the top of an engine and the other ends are supported from hooks in a horizontal beam. The hooks are 10 ft. apart, one chain is 9 ft. and the other 11 ft. long, and the engine weighs 20 cwt. What is the tension in each of the chains?

(4) A cylinder cover weighing 10 cwt. is suspended vertically by a rope 10 ft. long attached to an eyebolt on the cover. A second rope fastened to the eyebolt is pulled horizontally until the cover is moved sideways through 3 ft. What is the magnitude of the forces in the two ropes?

(5) A rope is suspended between two walls A and B and two weights 40 and W lb. are fastened to two points C and D so that AC inclines at 50 degrees and CD at 20 degrees each with the ground. DB is inclined at 50 degrees with the wall. Calculate the magnitude of the weight W.

(6) A rope is suspended between two supports in the same horizontal line 40 ft. apart. A weight of 1 ton is attached to a point on the rope at a horizontal distance of 10 ft. from one support. If the weight is 10 ft. below the points of attachment at either end, what is the tension in each rope?

(7) A sailing boat is being manoeuvred into position in a stream by two men. One is pulling on a rope, attached to the bow, making an angle of 20 degrees to the bank, and the other is fending the boat off the bankside with a boat hook which he applies at right angles to the bank. The pull in the rope is 50 lb. What is the force urging the boat along and the push exerted in the boat hook?

(8) A box weighing 15 lb. is resting on the ground and two ropes are attached to the top, passing over pulleys on an overhead beam to each of which a pull of 10 lb. is applied. At what equal angles to the vertical should the ropes be so that the box is just lifted off the ground?

ANSWERS TO EXERCISES IN LESSON 3

(1) 1 pound wt. (2) 120 pounds wt.; zero.
(3) 6·7 pounds wt.
(4) 17·5 ft./sec. at 14° 34′ West of North.
(5) 45° to the bank upstream. (6) 880 ft.
(7) 16° 40′ east of south.

LESSON 5

The Principle of Moments

In the preceding Lesson the analysis was confined to those systems in which the line of action of all the forces acted through a common point; in this Lesson are considered those force systems in which the forces do not intersect at a common point.

Moment of a Force

If a force in acting on a body tends to cause rotation of that body, it is said to possess a *Moment*. This moment depends upon the magnitude of the force and upon the perpendicular distance between the line of action of the force and the axis of rotation.

Fig. 21 shows a body free to rotate about a point O. F is a force acting on the body, OA is the perpendicular distance between the line of action of the force CD and the axis O. Then

$$\text{Moment of } F = F \times OA$$

To state the units in which a moment is given it is necessary to mention both the units of the force and the units in which the distance is measured. Hence if in Fig. 21 F is expressed in pounds and OA in feet the moment would be in lb.-ft. Other units which may be used are lb.-in., ton-ft., gram-centimetre, etc. The sense of a moment is best expressed by reference to the hands of a clock: the moment will tend to produce a rotation clockwise or anti-clockwise.

If a number of forces act on a body and all tend to produce rotation, the resultant will be found by first calculating the moment of each of the forces and then by taking the sum. Those forces tending to produce a clockwise rotation are designated positive, those tending to produce an anti-clockwise rotation are called negative. If the resultant is zero, then the body will be in equilibrium as regards rotation. This leads to the statement that *a body will be in equilibrium as regards rotation provided the sum of the clockwise moments is equal to the sum of the anti-clockwise moments.* This is called the *Principle of Moments.*

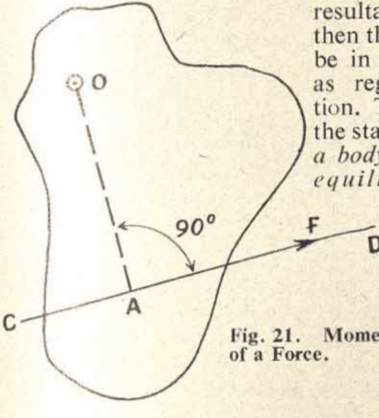


Fig. 21. Moments of a Force.

In Fig. 22 is a plank supported at a point O so that it is free to see-saw. W_1 and W_2 are weights placed at each end. The weight W_2 produces a clockwise moment equal to $W_2 \times OB = W_2 \times b$, and the weight W_1 an anti-clockwise moment equal to $W_1 \times AO = W_1 \times a$.

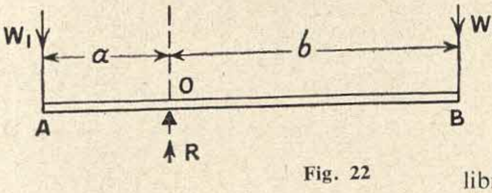


Fig. 22

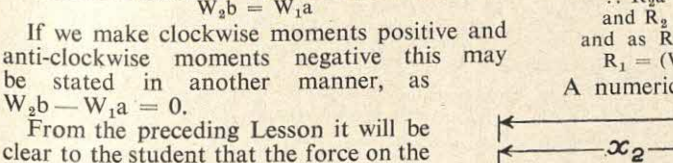


Fig. 23

For the plank to be in balance, i.e. equilibrium

$$\text{Clockwise moments} = \text{Anti-clockwise moments}$$
$$W_2b = W_1a$$

If we make clockwise moments positive and anti-clockwise moments negative this may be stated in another manner, as $W_2b - W_1a = 0$.

From the preceding Lesson it will be clear to the student that the force on the fulcrum will be equal and opposite to the sum of the forces acting on the plank, i.e. $R = W_1 + W_2$.

Fig. 23 shows a rod or bar supported in the centre and carrying two equal weights, one at each end.

It will be in equilibrium because the clockwise moments equal the anti-clockwise moments $Wa = Wa$, and the reaction R at the fulcrum O equals 2W.

Consider now the same three forces W, W, and R acting on the bar but with the axis of rotation moved to a point Ox at a distance x from the end of the bar. Taking moments about this new point Ox

$$\text{Clockwise moments} = R \times (x + a)$$
$$\text{Anti-clockwise moments} = Wx + W(a + a + x)$$

Equating these

$$R(x + a) = Wx + W(2a + x)$$
$$\text{as } R = 2W$$
$$2W(x + a) = Wx + W(2a + x)$$
$$2W(x + a) = 2W(x + a)$$

Therefore the bar is still in rotational equilibrium irrespective of the position selected for x. In fact, the system would be in equilibrium for any position chosen for Ox provided it is in the same plane as the other forces.

From examination of these results and from the preceding lesson it can now be stated that for a body to be in equilibrium under a system of forces

(1) *The algebraic sum of the vertical forces must be zero;*

(2) *The algebraic sum of the horizontal forces must be zero;*

(3) *The algebraic sum of the moments about any point must be zero.*

Fig. 24 shows a beam (the weight of which will be neglected) supported by two walls. It carries three loads, W_1, W_2, and W_3. The problem is to determine the load carried by each of the walls. As the system must be in equilibrium the algebraic sum of the moments about any point is zero, but it is most convenient to select a point coincident with one of the two resultants (or reactions).

Selecting the centre of wall A,

$$\text{Clockwise moments} = W_1x_1 + W_2x_2 + W_3x_3$$
$$\text{Anti-clockwise moments} = Ra$$
$$\therefore R_2a = W_1x_1 + W_2x_2 + W_3x_3$$
$$\text{and } R_2 = \tfrac{1}{a}(W_1x_1 + W_2x_2 + W_3x_3)$$
$$\text{and as } R_1 + R_2 = W_1 + W_2 + W_3$$
$$R_1 = (W_1 + W_2 + W_3) - R_2$$

A numerical example is now given to help

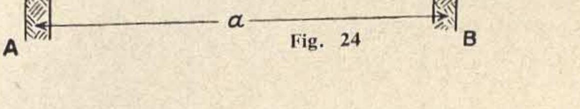


Fig. 24

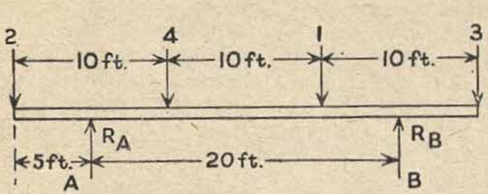


Fig. 25. Loaded Beam supported at two points.

the student understand the application of the Principle of Moments. Fig. 25 represents a beam resting on two walls and supporting four loads of 2, 4, 1, and 3 tons. The problem is to determine the reaction on each wall.

Taking moments about the point of reaction R_A offered by the wall A,

Clockwise moments = Anti-clockwise moments.
$(4 \times 5)+(1 \times 15)+(3 \times 25) = (2 \times 5)+(R_B \times 20)$
$20 + 15 + 75 = 10 + 20R_B$
$20 + 15 + 75 - 10 = 20R_B$
100 ton-ft. $= 20R_B$ ton-ft.
$\therefore \quad R_B = 100/20 = 5$ tons
Now, $R_A + R_B =$ the sum loads on the beam
$\therefore \quad R_A + R_B = 2 + 4 + 1 + 3 = 10$ tons
thus if $R_B = 5$ tons, $R_A \quad = 10 - 5 = 5$ tons.

This may be checked by taking moments about the wall B. As before,

Clockwise moments = Anti-clockwise moments
$(R_A \times 20)+(3 \times 5) = (1 \times 5)+(4 \times 15)+(2 \times 25)$
$20R_A + 15 = 5 + 60 + 50$
$20R_A = 5 + 60 + 50 - 15$
$\therefore \quad R_A = 100/20 = 5$ tons.

Two parallel equal forces opposite in sense are known as a *Couple*. The moment of a couple is the product of the magnitude of the forces and the perpendicular distance between them. Consider the couple illustrated in Fig. 26.

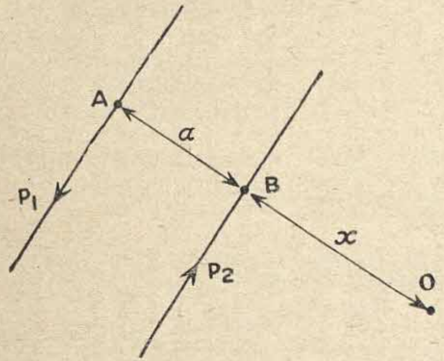


Fig. 26. A couple has the same moment about any point in its plane.

Taking moments about A,

$= - P_2a$

The negative sign indicating anti-clockwise moment)

Moments about B $= -P_1a$
and again about any point 0
$= (P_2 \times X) - P_1(x + a) = P_2x - P_1x - P_1a$
as $P_2 = P_1$
this becomes $- P_1a$

Thus the moment of a couple is the same about any point in its plane and it has a magnitude equal to the forces multiplied by the perpendicular distance separating them.

The student should note that a couple cannot be balanced by any single force.

It must be emphasised that, in calculating the moment of a force, it is the perpendicular distance between the line of action of the force and the point about which the moment is considered that must be used.

The lever AOB (Fig. 27) is pivoted at the point O. Forces P and Q are applied at A and B respectively. The solution may be found by drawing the lever to scale.

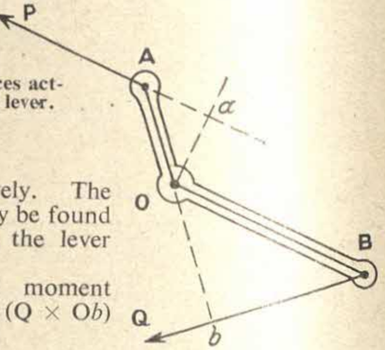


Fig. 27. Forces acting on a bent lever.

Resultant moment about O = (Q × O*b*) −(P × O*a*).

EXERCISES

(1) A horizontal bar 10 ft. long is pivoted at its centre. A weight of 20 lb. is suspended from one end. A second weight, of 50 lb., is hung 3 ft. from the pivot and on the same side of the pivot as the 20 lb. weight. What load is required at the opposite end of the bar to give rotational equilibrium ?

(2) A beam 18 ft. long supported at its ends carries loads of 2, 6, and 8 tons, at 3, 9, and 15 ft. respectively from one support. Find the reaction of the supports. Neglect the weight of the beam.

(3) A man weighing 15 stone supports himself from a horizontal bar in a gymnasium so that his feet are clear of the floor. What are the reactions at the supports (a) when he is at the centre of the bar, (b) when he is one-third of the length of the bar from one end ?

(4) A man and a boy carry a ladder horizontally between them. The weight of the ladder is 30 lb. and acts at the centre of its length. If the boy is at one extreme end, where must the man be if he is to support two-thirds of the load ?

(5) A square plate of 2-ft. edge is free to pivot. It is loaded as shown at Fig. 28. What moment must be applied to maintain rotational equilibrium ?

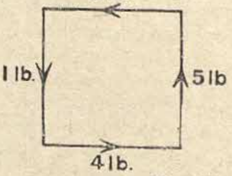


Fig. 28

(6) A beam 30 ft. long is supported at end A and at 20 ft. from end A. The beam itself weighs 1 ton which acts at the centre, i.e. 15 ft. from each end. It carries four loads, of 1, 2, 3, and 1 ton, at 1 ft., 2 ft., 6 ft., and 30 ft. respectively

from end A. What is the reaction at the supports?

(7) A rod carries loads of 3, 10, and 15 lb. at 10, 20, and 30 in. respectively from end A. Find the point at which the rod will balance. Neglect the weight of the rod.

ANSWERS TO EXERCISES IN LESSON 4

(1) 12 lb. ; 8 lb. (2) 24 lb. ; 24 lb.
(3) 7·8 cwt. ; 14·8 cwt.
(4) 10·48 cwt. vertically ; 3·145 cwt. horizontally.
(5) 58·13 lb. (6) 1·061 tons ; 0·7905 tons.
(7) 46·98 lb. ; 17·10 lb. (8) 41° 24′.

LESSON 6

Centre of Gravity and Stability

EVERY body may be considered as being made up of a number of particles each having a small weight w. All these forces may be illustrated by parallel vectors, and the sum of all these will be the resultant force due to gravity on the combined weight of all the particles. The point at which the resultant force can be considered as acting is known as the *Centre of Gravity* of the body.

Strictly speaking, this term is misleading and a better expression is "Centre of Mass" or simply "Mass Centre." Fig. 29 shows a uniform rectangular rod of wood resting on a knife edge. Consider a number of thin strips each weighing w so that the total sum of all the w's equal the total downward weight W. The rod can be supported on the knife edge at a point where it exactly balances. This means that it is in equilibrium at this point and that the reaction of the knife edge on the rod is $R = W$ and acts vertically upwards. The strips shown shaded at the extreme ends of the rod exercise moments about the point of support which are exactly equal and opposite in their effect. Similarly, any other two strips can be considered and it will be seen that their moments about the same point balance each other out.

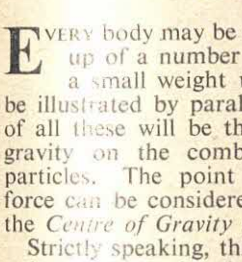


Fig. 29

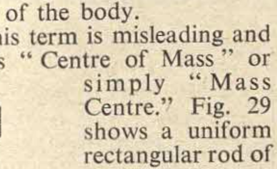


Fig. 30

CENTRE OF GRAVITY. Fig. 29. Uniform rod considered as a number of thin strips on a knife edge. Fig. 30. Rod not uniform.

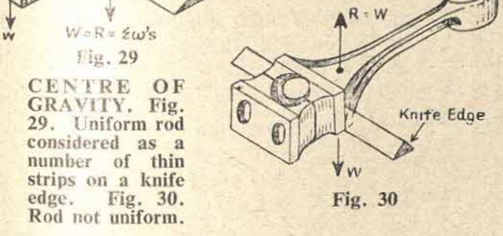


Fig. 31. G for a rectangular sheet of tin is in centre.

Thus the mass centre is a point about which the total sum of all the moments of the individual particles is zero, i.e. at the knife edge. In this particular case, because the rod is of uniform section, the centre of gravity, or mass centre, occurs at the centre of length.

When the body is not uniform in section—as, for example, a connecting rod of a motor car engine, shown in Fig. 30, the centre of mass is not at the mid-length but at a point G nearer the "thick end." The same principle holds good, however, and the connecting rod balances at G because the sum of all the clockwise moments produced by all the small particles of weight on the right-hand side of the knife edge exactly equals the sum of the anti-clockwise moments on the left-hand side.

Now consider a thin sheet of tin in the form of a rectangle, shown in Fig. 31. Take a thin uniform strip such as EF, parallel to the edge AB. Then from above, because it is uniform, its centre of gravity g occurs at mid-length. All such strips parallel to AB give a series of g's which lie on the straight line XY. Now consider the strips taken parallel to the side AC, of which GH is an example. The centre of gravity of GH lies at its mid-length at g_1. All these g_1 values lie on the straight line RS. It follows that the centre of gravity of the whole sheet must lie on the intersection of XY and RS at G. When the sheet becomes infinitely thin it may be described as a plane lamina or plane area of no weight at all, and its G now becomes the "centre of area" and, incidentally, lies on the intersection of the diagonals AD and BC.

Fig. 32 shows a plane lamina in the form of a triangle. As before, consider strips parallel to the side BC. The centre of length of each of these strips locates a g value, and the series of g's will lie on a line joining A to the middle point of the base at E. This line AE is

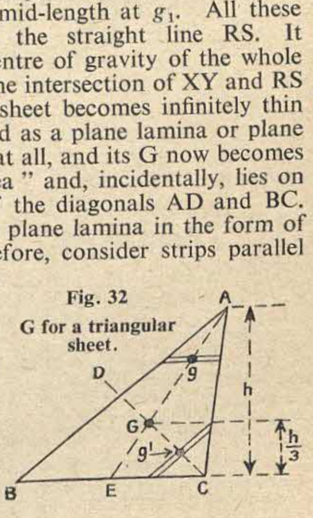


Fig. 32
G for a triangular sheet.

called the *median*. Now take strips parallel to the side AB, and a new series of g^1 values will be found to lie on the median CD. The intersection of these two medians at G will locate the centre of area of the triangle. It will be found that this point G lies exactly at $\frac{1}{3}$ of the length of the median from the base in each case, and also exactly at $\frac{1}{3}$ of the perpendicular height of the triangle up from the base.

In calculating the centre of mass or area of irregularly shaped figures it is usual to imagine them to be divided into regular areas and then to apply the principle that the sum of all their individual moments about any point is zero. In Fig. 33 suppose a sheet of tin is cut to the form ABDE. This shape may be divided conveniently into a triangle and a rectangle. The centre of mass of the triangle located at G_1 lies at the intersection of the medians and the centre of mass of the rectangle at G_2 lies on the intersection of the two diagonals.

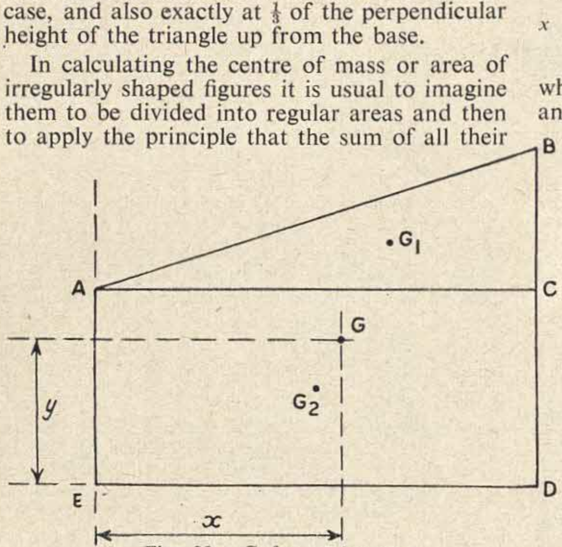


Fig. 33. G for an irregular-shaped figure.

If G is the centre of mass of the shape it follows from what has been said previously that it must have the same moment about a point as the sum of the moments of G_1 and G_2. To determine the position of G it is necessary to take moments about two axes at right angles to each other. Any two axes may be chosen, but it is usually convenient to choose two sides of the figure, in this case DE and EA.

Moments about DE

$$y \times (\text{area ABDE}) = \tfrac{1}{2}\,\text{CD} \times (\text{area ACDE}) + (\tfrac{1}{3}\,\text{BC} + \text{CD})\,(\text{area ABC})$$

$$\therefore y = \frac{\tfrac{1}{2}\,\text{CD} \times (\text{area ACDE}) + (\tfrac{1}{3}\,\text{BC} + \text{CD})\,(\text{area ABC})}{\text{area (ABDE)}}$$

Moments about AE

$$x\,(\text{area ABDE}) = \tfrac{1}{2}\,\text{ED}\,(\text{area ACDE}) + \tfrac{2}{3}\,\text{AC}\,(\text{area ABC})$$

$$\therefore x = \frac{\tfrac{1}{2}\,\text{ED}\,(\text{area ACDE}) + \tfrac{2}{3}\,\text{AC}\,(\text{area ABC})}{\text{area ABDE}}$$

Since the weight of a thin laminae is proportional to the area, it follows that weight can be substituted for area without influencing the result. In general terms:

The sum of the individual moments of area or weight = the total area or weight × x, where x is the distance of the centre of gravity or area of the whole figure from the selected moment point. Therefore

$$x = \frac{\text{Sum of the individual moments of area or weight}}{\text{Total area or weight.}}$$

A body is said to be in *stable equilibrium* if, when rotated slightly through a small vertical angle, it immediately possesses a "righting moment" which tends to return the body back into its original position. In Fig. 34 a side view of a four-legged chair is shown (with only two legs visible) upon which a person is seated. The combined weight of the chair and occupant is W and the combined centre of gravity is located at G. From what has been previously said, the weight W will act vertically through G and the floor exerts reactions of R_1, R_2, R_3 and R_4 upwards through the legs.

If the chair is tipped on to the back two legs through a small angle as shown in Fig. 35, then immediately the reaction from the floor is transferred to the back legs and it can be seen that a clockwise moment of W × x is produced which tends to rotate the chair and occupant back on to the four supports. Thus the chair is *stable* in this position.

In Fig. 36 the chair has been tipped back until the weight W through G is vertically above the reaction points R, and now the system is in *unstable equilibrium* because with a slightly further rotation the vertical force through G appears outside the reaction and produces an upsetting moment of W × y which tends to rotate the chair still further, as shown in Fig. 37.

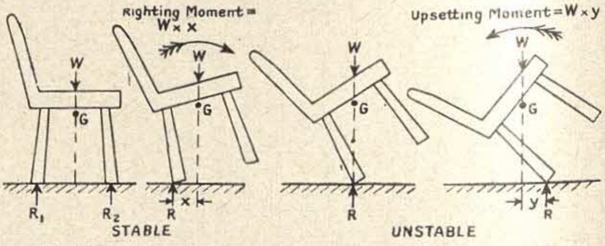


Fig. 34 Fig. 35 Fig. 36 Fig. 37

STABILITY. Four positions of a chair. Figs. 34 and 35, stable because G is inside reaction points R_1, R_2. Figs. 36 and 37, unstable because upsetting moment exceeds righting moment.

It is obvious that the position of G and the design of the base of the chair will considerably influence its stability. If the legs are well spread out and G is very near the ground, then the chair will have to be put through a very large angle before it will overturn. Conversely, with

G far from the ground and the legs close together a very small angle will make the system unstable.

Modern car design tends to very low frames and big wheel bases for these reasons.

EXERCISES

(1) Find the centre of area of a T-shaped lamina if the cross piece measures 4 in. by 2 in. and the vertical piece 6 in. by 2 in.

(2) Find the position of the centre of mass of a shaft 6 ft. long weighing 50 lb. upon which is mounted a circular disk at 2 ft. from one end weighing 15 lb.

(3) A bar-bell used in a gymnasium consists of a steel rod weighing 12 lb., on the end of which are two cast-iron balls. If one ball weighs 20 lb. and the other 22 lb. and the distance apart from centre to centre is 4 ft., where must the bar be lifted so that it rises horizontally from the ground ?

(4) A rectangular crate measuring 6 ft. by 4 ft. by 2 ft. is standing up on one of the 4 ft. by 2 ft. ends. Assuming that the centre of mass lies on a vertical line passing through the centre of the two ends, what is the angle to which the crate can be tilted on its 4-ft. edge so that it just becomes unstable if *g* is (*a*) 2 ft., (*b*) 3 ft., (*c*) 4 ft. up from the base ?

ANSWERS TO EXERCISES IN LESSON 5

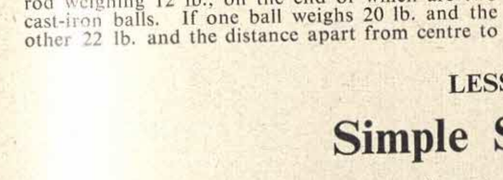
(1) 50 lb.
(2) 6 and 10 tons.
(3) (*a*) 7½ and 7½ stones ; (*b*) 10 and 5 stones.
(4) ¾ of the length of the ladder from the boy.
(5) 12 lb.-ft. (clockwise).
(6) 4·6 and 3·4 tons.
(7) 24·3 in. from end A.

LESSON 7

Simple Structures

A STRUCTURE is an arrangement of parts assembled in such a manner that no relative motion (other than the small amounts due to the elasticity of the components used) takes place when the structure is loaded. The structures considered in this Lesson consist of bars assumed to be connected together by pin joints (i.e. joints that cannot transmit a moment) and carrying loads at these joints. The components of such a structure will be subject only to simple push or pull forces.

There are three classes of structure: deficient, simple, and redundant. Remembering that the members of the structures are connected by pin joints the classes may be defined as:



CLASSES OF STRUCTURE. Fig. 38, a, deficient ; b, simple ; c, redundant.

Deficient. Structures in which the parts are capable of relative motion are known as deficient. Fig. 38a is an example of such a structure ; it will be obvious to the student that it would be unable to support a load.

Simple. Simple or simply firm structures are deficient structures with only one extra member. A frame of this class has just sufficient members to retain its shape under load.

Redundant. A redundant structure has more members than are necessary to maintain its shape under load.

Redundant frames present complex calculations in their design, therefore it will be sufficient in this introduction to consider simple structures only.

Many of the associated problems which arise with forces acting at a point that is in static equilibrium are greatly simplified by the use of Bow's method of notation. Fig. 39 shows, in a *space diagram*, a point O in equilibrium under the action of three forces P, Q, and R, the directions of which are indicated by the slopes of the lines, and the senses by the arrow heads placed on the lines. Place capital letters, A, B, and C, in the spaces between the forces and now each force is designated by the letters on either side of it. Thus the force P is now known as *a b*, using small letters, similarly R is *b c*, and Q is *c a*. Now proceed round the point O in a clockwise direction and draw a force diagram, Fig. 40. From A to B the force P is crossed, so draw a line equal in magnitude to P to some convenient scale and parallel to P in direction and label it *a b*. The sense of it is from *a* to *b*, so an arrow head appears to show that P is a pull at the point O in that direction. Next, go from B to C when the force R is crossed and draw in a line *b c* equal to R in magnitude to the same scale as P and parallel to R's direction. The arrow head on it shows that it is a pull from *b* to *c* indicating that R is pulling outwards from O. Finally, proceed from C to A when the force Q is crossed, and

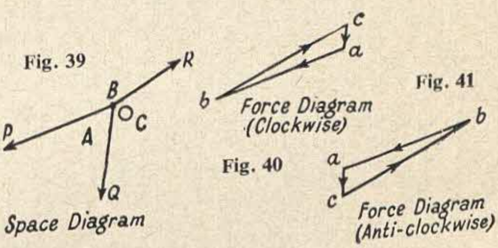


Fig. 39 Fig. 40 Fig. 41

BOW'S NOTATION. Fig. 39. Space diagram of three forces shown in Fig. 40 in Bow's method (clockwise), in Fig. 41 similarly but anti-clockwise.

the line *c a* parallel to the direction of Q and equal in magnitude to it, to the same scale, will complete a triangle of forces since O is in equilibrium. The arrow head on *c a* from *c* to *a* indicates that the force Q is pulling downwards from O. Thus the triangle *a b c* is the force diagram giving all the information required about the forces at point O.

A similar diagram would have resulted if the rotation round the point O had been in an anti-clockwise direction as shown in Fig. 41 so that the notation holds good provided there is no reversal of direction while proceeding round the point. In Fig. 41 the interpretation is from *b* to *a*, *a* to *c*, and *c* to *b* ; notice again that the arrow heads chase one another round the figure.

Figs. 42, 43, and 44 are examples of simple frame structures. The Warren and the N girders are commonly used in bridge design ; the last example is a typical roof truss.

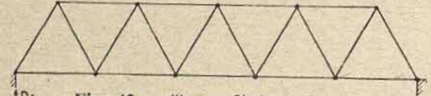


Fig. 42 *Warren Girder*

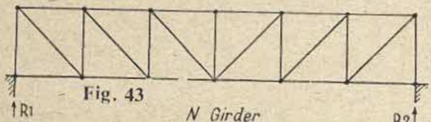


Fig. 43 *N Girder*

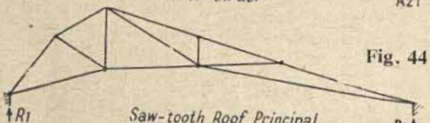


Fig. 44 *Saw-tooth Roof Principal*

SIMPLE FRAME STRUCTURES. Three examples of frameworks in equilibrium by sound mechanical design. Fig. 42, the Warren Girder, and Fig. 43, the "N" Girder, are used to support loads over moderate spans. Fig. 44, the Saw-tooth Roof Principal.

The problem is to calculate the magnitudes of the forces which occur in the individual members and to determine their directions, whether they are ties (in tension) or struts (in compression), so that they can be economically designed, since ties are lighter sections than struts. In the solution, the forces involved may be divided into two groups. The *external forces* include all the outside loading applied together with the reactions produced at the supports. The *internal forces* include all the pushes and pulls to which the various members are subjected under the external loading.

Considering the frame as a whole, these external forces must be in equilibrium quite independently of the shape or the arrangement of the component members, and so the principles previously explained may be applied in order to determine the reactions at the supports. It is also apparent that every joint in the system is also in equilibrium under the internal forces in the bars at the joint, together with any external loading at the joint. The complete solution is very much simplified graphically by the use of Bow's Notation.

Fig. 45. Diagrammatic structure of a crane. Fig. 46. Force diagram of the crane shown in Fig. 45.

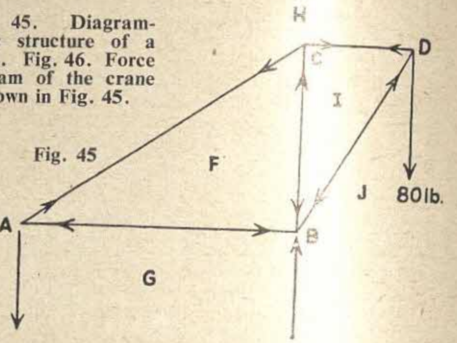


Fig. 45

The following typical example explains the general method. Fig. 45 shows diagrammatically a simply firm structure of a crane anchored at points A and B. An external load of 80 lb. is supported on the end of the jib. Using Bow's Notation, letter the spaces between all the forces with capital letters, say : F, G, H, I, and J. Each of the forces or members can now be described by the two capital letters it lies between, e.g. the load of 80 lb. is indicated by HJ, the vertical member of the frame by the letters FI, etc.

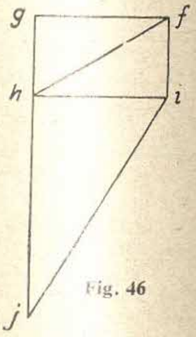


Fig. 46

Now consider the internal forces, by starting at one joint where there are not more than two unknowns and proceed round the joint in one direction, say clockwise. This direction must be observed throughout the solution. An obvious point to start is D. Choose a convenient scale and draw the force diagram for the joint D. Thus *hj* (Fig. 46) is the force of 80 lb. between H and J from *h* to *j* ; *j i* is the force in the bar BD between J and I in direction parallel to BD but magnitude unknown, but *i h* the force in the bar CD has a direction horizontally and the force figure must be a closed one, so a line drawn horizontally through *h* meets *j i* at *i* and therefore the triangle *h j i* represents the force figure for the three forces in equilibrium at point D. By measuring with a rule the lengths of the lines *j i* and *i h* the magnitudes are obtained at once.

The senses of the forces are determined by repeating the lettering on them. Thus force *i h* (the clockwise rotation chosen) means from *i* to *h* ; in other words, the force is pulling towards the left from D and so the bar CD is a tie, which means that it is also pulling away from C at its other end. This is clearly indicated by arrow heads placed on the bar facing one another. The force *j i* (again observing the clockwise rotation chosen) means from *j* to *i*; in other words, the force in BD is pushing on to the joint at D and therefore the bar BD is a strut, which must be equally pushing at its other end on to joint B, and this sense is indicated by arrow heads pointing away from one another.

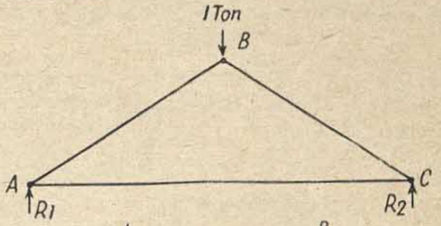
This completes the solution of the joint D, so now proceed to C, where the force *h i* is already known, thus leaving the requisite two unknowns to be determined. Proceed in exactly the same way moving clockwise round the joint and draw the triangle *h i f*, which, measured to scale, gives the forces in the *strut* BC and the *tie* AC. Next to joint B, where three of the four forces have already been found, draw the polygon *i j g f*. This really completes the solution of the whole frame because all the forces at A appear on the diagram; the reaction on the hinge *g h* can be measured.

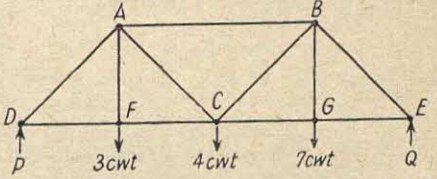
The student is recommended to copy the figure out to as large a force scale as possible and to check the answers obtained before attempting further problems.

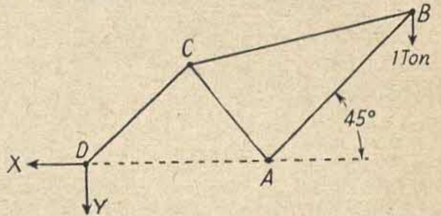
EXERCISES

(1) A simple roof frame is in the form of an isosceles triangle ABC and carries a load of 1 ton at the apex B. By a graphical method, using Bow's notation, find the values of the reactions at the supports and the forces in the members AB = BC = 12 ft., AC = 20 ft.

(2) For the framework shown in which the angles are 45° and 90°, find graphically the reactions P and Q: confirm by taking moments. Determine the forces in AB, BC and CA, stating which are ties and which struts.







(3) Find the forces X and Y, the reaction at A and the force in CD, when A is fixed and the framework supports 1 ton wt. AB = BC = 20 ft., AC = 9 ft., CD = 10 ft.

ANSWERS TO EXERCISES IN LESSON 6

(1) 4·6 in. up from the bottom of the vertical leg.
(2) 2·77 ft. from the end of the shaft nearest the disk.
(3) 1·905 ft. from the centre of the heavier weight.
(4) (*a*) 63° 28′; (*b*) 71° 34′; (*c*) 75° 58′.

LESSON 8

Elementary Notions of Momentum

THE term projectile usually refers to a body which is expelled by a sudden force from a relatively fixed source. Apart from the obvious example of a shell from a gun, or a bullet from a rifle, there is also a jet of water from a nozzle, and a ball flung from the hand. In each case the moment the projectile is released from the fixed source it is subject to two independent velocities—the one produced by the original expelling force, and a second produced by the acceleration caused by the earth's gravitational pull.

The actual path taken by the body is a curved one of *parabolic* form. The path of the jet of water from a garden hose, or of a cricket ball flung into the air, is shown in Fig. 47. These two velocities are quite independent of each other, and the path of the body can be calculated by considering the displacements produced by each separately.

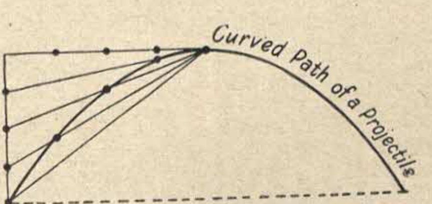
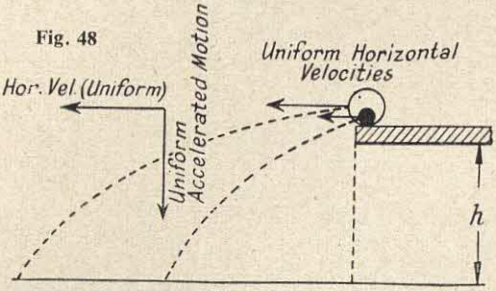


Fig. 47. The path of a projectile when calculated is shown to be a parabolic curve.

This fact can be demonstrated quite simply. Roll two balls across a table, giving one a greater velocity than the other, but arrange that both leave the edge of the table together. It will be found that both balls reach the ground at exactly the same time, although each has a different parabolic path. This means that the velocity towards the ground, which comes into action the moment the restraint of the table ceases, produces exactly the same result on each ball irrespective of their forward velocities (this is shown in Fig. 48). Both balls reach the ground in exactly the same time as if they had been dropped vertically together over the table edge. Knowing the height of the table *h* feet,

Fig. 48



GRAVITY AND PROJECTILES. Fig. 48. Despite differing parabolic paths, action of gravity produces uniform acceleration downwards with differing uniform horizontal velocities.

and the horizontal velocity of the ball *v* at the moment it leaves the table, then from the vertical accelerated motion of gravity

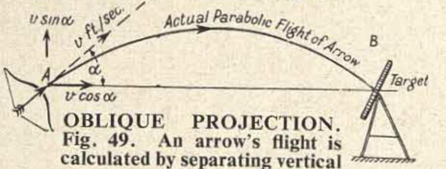
(From Lesson 2) $h = ut + \frac{1}{2}gt^2$, in this case $u = o$

$\therefore h = \frac{1}{2}gt^2$ and $t = \sqrt{\frac{2h}{g}}$

hence the time *t* seconds to reach the ground, and in this time *t* secs. at uniform velocity *v* ft. per sec. the horizontal distance travelled is *vt* before reaching the ground.

If the body is projected obliquely instead of horizontally—say, for example, in archery—at a uniform velocity and at an angle α to the horizontal, as shown in Fig. 49, it is convenient to split up the forward velocity into two distinct components.

Fig. 49



OBLIQUE PROJECTION. Fig. 49. An arrow's flight is calculated by separating vertical and horizontal velocities.

Vertically the velocity is $v \sin \alpha$ and horizontally, v cosine α. Also from Lesson 2

$$h = \frac{v^2}{2g}$$

Thus the maximum height reached by the arrow

$$= h = \frac{1}{2g}(v \sin \alpha)^2$$

The time to reach the mid-point of the flight, i.e. that point at which maximum height is reached, is obtained from the formulae

$$t = \frac{v}{g}$$

Substituting for velocity $t = \frac{v \sin \alpha}{g}$

α total time of flight $= 2t = \frac{2}{g}(v \sin \alpha)$

therefore $\mathrm{AB} = \frac{2}{g}(v \sin \alpha)(v \cos \alpha)$

$$= \frac{2v^2}{g} \sin \alpha \cos \alpha$$

The total horizontal distance AB is called the *range*, and for any given velocity the greatest possible range is obtained when α is 45 degrees to the horizontal. Test this out with an ordinary garden hose pipe. The furthermost part of the lawn is reached when the nozzle is held at 45 degrees from the horizontal, as shown in Fig. 50.

When a golf club strikes a golf ball, the force produced on the ball acts only for a very short space of time—in fact, the force becomes a blow. The impulse of this force is measured by the product of the magnitude of the force (P) and the time during which it is in contact with the ball (t). Thus Impulse $= \mathrm{P}t$.

If u is the initial velocity of the ball, v the final velocity of the ball, m the mass of the ball, and a the acceleration produced by the force of P, now,

$$v = u + at \qquad \text{or,} \qquad a = \frac{v - u}{t}$$

$$\text{but,} \qquad \mathrm{P} = ma = \frac{m(v - u)}{t}$$

$$\text{or,} \qquad \mathrm{P}t = m(v - u) = mv - mu$$

But the product of the mass and the velocity is the momentum, and $mv - mu$ is the change of momentum, so,

$\mathrm{P}t =$ the change of momentum.

It is thus possible to measure the effect of a large force acting for a very small interval of time. For example, a stone of $\frac{1}{2}$ oz. mass is flung horizontally at a plate glass window at a velocity of 100 ft. per sec. Suppose the window brings the stone to rest in a definitely short time—say, $\frac{1}{100}$ sec.

Then the change in velocity is
$100 - 0 = 100$ ft./sec.

Mass of the stone is $\frac{1}{2}$ oz. $= \frac{1}{32}$ lb.

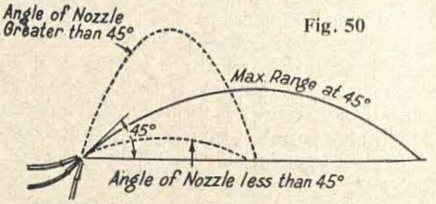
Then Impulse $\mathrm{P}t =$ change of momentum

$= 100 \times \frac{1}{32} = 3{\cdot}13$ lb. ft. sec. units.

but $t = \frac{1}{100}$ sec.

therefore, $\mathrm{P} \times \frac{1}{100} = 3{\cdot}13$

Fig. 50


Angle of Nozzle Greater than 45°
Max Range at 45°
45°
Angle of Nozzle less than 45°

MAXIMUM RANGE. Fig. 50. For any given velocity the greatest range is obtained when angle between horizontal and vertical velocities (Fig. 49) is 45 deg. Shown by garden hose.

and, $P = 3{\cdot}13 \div \frac{1}{100} = 313$ poundals,

or, $\frac{313'}{g} = \frac{313}{32{\cdot}2} = 9{\cdot}7$ lb. wt.

Alternatively,
to destroy the velocity from 100 ft./sec. to 0 ft./sec. in $\frac{1}{100}$ sec.

from $v = u + at$, the acceleration is negative (a retardation)

$$0 = 100 - \frac{a}{100}$$

from which, $a = 10{,}000$ ft./sec./sec.

and since $P = ma = 10{,}000 \times \frac{1}{32}$
$= 313$ poundals or $9{\cdot}7$ lb. wt.

so that the stone is producing on the plate glass momentarily a force equal to 9·7 lb. weight.

In the Pelton water wheel, water issues at a high velocity as a jet and impinges upon a series of specially shaped vanes or buckets fixed radially on a wheel, free to rotate. The change of momentum of the mass of issuing water produces a force on each bucket in turn.

Similarly, impulse steam turbines derive their power from steam issuing at high velocity from nozzles impinging on to blades arranged radially on the rim of a wheel free to rotate.

Impact of Two Bodies

It is a common experience in railway goods sidings to see a moving truck (A) collide with a stationary one (B) and then for both trucks to move on together in the same direction. From the third Law of motion, action and reaction are equal and opposite. Therefore the impulse of A on B is equal and opposite to that of B on A, and it therefore follows that the changes of momentum are equal and opposite. The sum of the two momenta, measured in the same direction, is therefore unaltered by the impact.

Suppose that truck A has a mass m and is moving with a velocity v, and truck B has a mass M, and velocity zero.

Then the total momentum before impact is $M \times 0 + m \times v = mv$.

If V is the velocity of both together after impact

Then the momentum after impact is $(M + m) \times V$.

and, Momentum before is equal to Momentum after and, therefore, $(M + m) \times V = m \times v$.

and, $$V = \frac{m \times v}{(M + m)}$$

This is the *Principle of the Conservation of Momentum.*

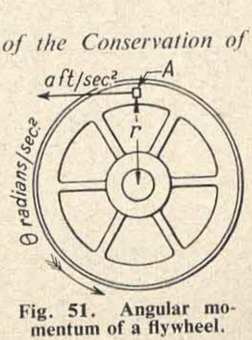


Fig. 51. Angular momentum of a flywheel.

Fig. 51 represents a flywheel subject to an angular acceleration of θ radians/second². Let A represent a small particle of mass m at a radius r from the centre of rotation. The lineal acceleration of this particle $a = \theta v$. From Lesson 2, $W = \frac{ma}{g}$, therefore the force required to give an angular acceleration of θ

$$= W = \frac{\theta mv}{g}$$

Multiplying this quantity by the radius of action r gives this load as a moment about the centre of rotation, i.e.

$$T = Wv = \frac{\theta mv^2}{g}$$

The total moment of resistance of the body is given by the expression

$$T = \Sigma t = \frac{\theta}{g} \Sigma mv^2$$

Note. The Greek letter Σ (sigma) signifies the "summation of."

The quantity Σmr^2 may be called the second moment of mass, or, more commonly, the *Moment of Inertia* of the body and is denoted by the letter I

$$\therefore T = \frac{\theta I}{g}$$

The analogy between this equation and the corresponding one for rectilinear motion should be noted :

Rectilinear Motion		Angular Motion
$W = \frac{ma}{g}$ pounds	:	$T = \frac{\theta I}{g}$ pound feet

It is beyond the scope of this Course to consider the determination of the Moment of Inertia of various bodies, therefore a table is given below of those Moments of Inertia most commonly encountered.

Solid Cylinder :

about axis of cylinder $I = \frac{MR^2}{2}$

where M = total mass and R = outside radius

Hollow Concentric Cylinder :

about axis of cylinder $I = \frac{M(R^2 + r^2)}{2}$

where M = total mass, R = outside radius and r = inside radius

Solid Sphere :

about any diameter $I = \frac{2MR^2}{5}$

where M = total mass and R = outside diameter.

Consider again the small particle A, Fig. 51, but now with a lineal velocity $v = wr$.

Then the lineal momentum $= mv = \omega mv$

To obtain the angular momentum this term must be multiplied by the radius :

Angular Momentum of particle $= \omega mv^2$ and the
Angular Momentum of the complete body $= \omega \Sigma mv^2$
as shown above $\Sigma mv^2 = I$
$\therefore$ *Angular momentum* $= \omega I$

The term Inertia is used here in exactly the same sense as before, and it refers to the inability of the wheel to start rotating, or, if in motion, to stop turning, unless acted upon by a force. So that the Moment of Inertia gives a measure of the turning force required to produce rotation or of the braking force necessary to bring the wheel to rest once it is in motion.

It is this property of the flywheel which produces smooth regular rotation when the turning impulses are irregular. That is to say, the flywheel stores up superfluous energy when the supply is in excess of requirements, and gives it out again when the supply falls short or momentarily ceases altogether. The ordinary motor car engine only supplies energy for one stroke in every four, or gives one impulse every two revolutions, so that a flywheel is essential for smooth running.

EXERCISES

(1) A stone is thrown horizontally from the edge of a cliff 100 ft. high at 50 ft. per second. Find the time taken to reach the beach below and the horizontal distance travelled by the stone.

(2) A rifle pointed horizontally, with its barrel 5 ft. above the surface of a lake, discharges a bullet which strikes the water 1,300 ft. off. What is the initial velocity of the bullet ?

(3) A cricket ball of 4 oz. weight travelling horizontally at 40 ft. per second is driven straight back to the bowler at a velocity of 80 ft. per sec. If the contact between the ball and the bat lasted for $\frac{1}{30}$ part of a second what is the average force acting on the blade of the bat ?

(4) A sledge hammer weighing 10 lb. strikes a steel chisel to drive it into a concrete road. The velocity of the hammer is 20 ft./sec. and the blow lasts $\frac{1}{40}$ part of a second. What is the impulse of the blow ?

(5) A truck weighing 5 tons, travelling at 2 miles per hour, collides with a second truck at rest and both move on together at 1 mile per hour. What is the weight of the second truck ?

(6) A gun weighs 4 tons and fires a shell weighing 30 lb. If the shell leaves the muzzle at 200 ft. per second what is the velocity of recoil of the barrel ?

(7) A wheel has a moment of inertia of 10,000 in pound and feet units, and is brought from rest to 200 revolutions per minute in 25 seconds. Calculate what steady moment must have acted on it.

ANSWERS TO EXERCISES IN LESSON 7

(1) Reactions ½ ton each, AB and BC struts 0·9 tons compression, AC tie 0·75 tons tension.

(2) Reactions, P 6 cwt., Q 8 cwt.
Forces, AC 4·25 cwt. tension, CB 1·2 cwt. tension, AB 9 cwt. compression.

(3) Reaction at A, 2·5 tons at 25½ degrees from the vertical.
Force in CD 1·7 tons.
Force X 1·2 tons.
Force Y 1·6 tons.

LESSON 9

First Principles of Friction, Work, and Energy

WHEN two bodies are in contact, and being pressed together, a force prevents, or tends to prevent, the body from sliding over the surface of the other. This force is due to friction and is called the *Force of Friction*. It always opposes the direction of motion and is a mixed blessing. Without friction it would be quite impossible to walk, vehicles would not move (their wheels would spin idly round), and the action of the brake on these revolving wheels would be quite ineffective. On the other hand, the existence of friction causes wear and tear in machinery parts, produces holes in shoe leather, wears down rail and tram tracks to a highly polished smooth surface, takes the tread off motor tires, and generates heat as a waste loss of valuable energy.

Laws of Dry Friction

As friction plays such an important part in the solution of so many mechanical problems it is necessary to examine this property more closely and to experiment with models to ascertain if any definite laws exist. An investigation shows that there is a distinction between *dry* friction conditions, where the surfaces in contact are quite free from any form of lubrication, such as railway wheels on steel rails, and shoe leather on dry pavements, and *fluid* friction, such as obtains with shafts revolving in well-oiled bearings, or gear wheels running in oil baths. The laws associated with each condition are quite different

Consider first the laws of Dry Friction. Fig. 52 shows a crate weighing W lb. resting on a railway platform. The *normal* pressure between the crate and the platform is R, which in this case is equal and opposite to W. R is the normal or perpendicular reaction of the ground on the crate. Directly a force P is applied to slide the crate along, an equal and opposite force F, due to friction, appears between the surfaces in contact. At first, when P is too small, no movement results, but presently, as P increases, a point is reached when the crate just begins to slide forward. Let this value of P equal P_s; the ratio of P_s and the normal reaction R is called the *coefficient of static friction*, denoted by the symbol μ_s (Greek letter μ, mu). Thus :

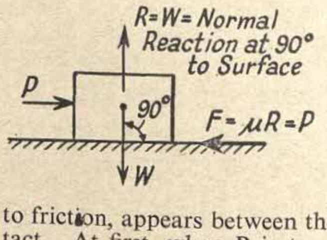


Fig. 52. Friction between crate and platform.

$$\frac{\text{The force to produce movement}}{\text{The normal reaction between the surfaces in contact}} = \frac{P_s}{R} = \mu_s$$

Having caused the crate to slide forward it is necessary to reduce the value of P in order to maintain uniform velocity. If this reduced value of P equals P_k then the ratio of P_k and the normal reaction R is called the *coefficient of kinetic friction*, denoted by the symbol μ_k. Thus:

$$\frac{\text{The force required to maintain uniform velocity}}{\text{The normal reaction between the two surfaces in contact}} = \frac{P_k}{R} = \mu_k$$

For clean dry surfaces it can be shown experimentally that *the force of friction is proportional to the reaction between the two surfaces in contact and is independent of the speed of rubbing and the area of the two surfaces.*

If, for example, in Fig. 53 the crate of the *same weight* W is in contact with the ground and providing that the nature of the two surfaces is as before, then the same force P exactly would be required to produce steady motion.

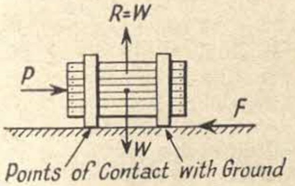


Fig. 53. Friction unchanged with reduced points of contact.

Coefficients of Friction

The value of the coefficient of friction cannot be predicted with accuracy. The table below gives average values for the coefficient of kinetic friction between dry surfaces.

	μ_k
Metal on metal	0·2
Metal on stone	0·5
Metal on wood	0·2—0·5
Metal on leather	0·3—0·5
Wood on wood	0·2—0·6

Recent advances in science have produced several anti-friction materials which exhibit very low coefficients of friction. The foremost of these is polytetrafluoroethylene (P.T.F.E.), a white, wax-like substance which against a metalic surface has a coefficient of kinetic friction of 0·05.

It is of interest to follow the action of a bicycle on the road. Fig. 54 is a sketch of a back wheel and driving chain. A force P is applied to the pedal which communicates to the back sprocket a tension T inducing the wheel to rotate on its axle. Part of the weight of the machine and rider communicates a normal pressure W to the road and an equal and opposite reaction R from the road. With no friction present the wheel would simply spin idly round on the same spot, as is the experience when the surface is greasy or wet. With friction, a force F appears equal to μ R, where μ is the coefficient of friction between rubber and road surface. This force F is in the direction of the moving machine and urges it forward. It has a limiting value, as explained before, which cannot be exceeded, and if the pressure is greater than required for this force the wheel begins to skid.

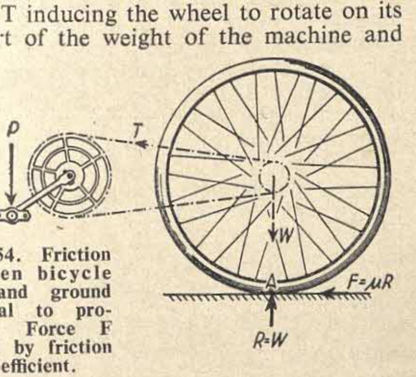


Fig. 54. Friction between bicycle tyre and ground essential to progress. Force F limited by friction coefficient.

The Friction Angle

Suppose now that the crate in Fig. 52 is placed on a platform one end of which can be slowly elevated. As the end is gradually raised the action of gravity tends to pull the crate down the slope, but the friction force between the two surfaces in contact opposes this movement and stops the crate from moving.

As the angle of the incline is increased, the pull exerted by gravity becomes greater, until the value is exactly equal and opposite to F, the limiting force of friction. At this point the crate begins to slide slowly down the inclined plane. This particular angle is denoted by the Greek letter λ (lambda) and is the limiting angle of friction, or just simply the *friction angle*.

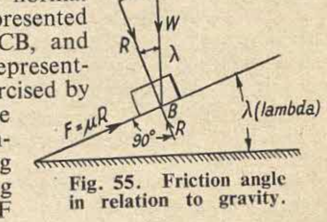


Fig. 55. Friction angle in relation to gravity.

Examine Fig. 55, which shows the inclined plane at this angle λ. The weight of the crate W acts vertically downwards and is represented by the *vector* AB. The normal reaction R is represented by the vector CB, and CA is a vector representing the force exercised by gravity urging the crate down the incline. Opposing this is the limiting friction force F equal to μ R. The reaction of the plane is equal and opposite to R. It can be seen that the angle CBA between W and R is equal to λ and that

$$\frac{CA}{CB} = \frac{CA}{R} = \tan\lambda$$

$$\text{but } CA = \mu R = F$$

$$\text{therefore } \frac{F}{R} = \frac{\mu R}{R} = \mu = \tan\lambda$$

in other words, *the tangent of the friction angle is equal to the coefficient of friction.*

It should be noted that in this example the symbol μ has been used without the suffix *s* or *k*. If the angle λ is increased until the crate begins to slide, then $\tan\lambda = \mu_s$; if, however, the angle λ is set so that the crate once started will continue to slide at a uniform velocity, then $\tan\lambda = \mu_k$. When sand is heaped up, the sides of the cone thus formed reach a limiting angle of

λ with the road, after which if more sand is piled on it simply slides down the sides. This *angle of rest* of the material depends upon the μ value of sand upon sand. Railway cuttings and embankments are always designed so that the slope of the earth does not exceed the particular appropriate value of λ for fear of landslides.

Laws of Fluid Friction

The laws of Fluid Friction, except for the problems of lubricated bearings, can be studied separately under the subject of Mechanics of Fluids, but it is as well at this point to make a comparison.

With fluid friction the force is directly proportional to the " wetted surface " ; it varies as the velocity to some power n (v^n), is also proportional to the density of the liquid, but is independent of the pressure to which the liquid is subjected.

Meaning of " Work "

In mechanics the term " work " has a very definite and precise meaning. The mechanical definition says that when a force moves through a distance overcoming a resistance, work is said to be done, and the magnitude of the work done is the product of the force and the distance the force moves through.

More accurately,

Work = Force × Distance, the point of application moves *in the direction of the force.*

The units of work must therefore be of a dual character, and are generally expressed in *foot-pounds*. The units, however, may equally well be expressed in *inch-pounds*, or *inch-tons*, etc., corresponding to the units of distance and force employed. If a lift containing 10 people, each weighing 140 lb., is raised through 20 ft., then $140 \times 10 \times 20 = 28{,}000$ ft.-lb. of work has been expended. If the crate in Fig. 52 or 53 weighs 1 cwt., the coefficient of friction μ is 0·4, and the crate is moved 5 ft., then work done is

$$\begin{aligned} F \times 5 &= \mu W \times 5 \\ &= 0{\cdot}4 \times 1 \times 5 \\ &= 2 \text{ ft.-cwt. or } 224 \text{ ft.-lb.} \end{aligned}$$

Definition of " Energy "

The mechanical definition of this term is simply " capacity for doing work." In ordinary conversation the same meaning persists, and an " energetic " person is one possessing a full measure of desire and ability to do work. In mechanics, however, it is necessary to differentiate between two forms of energy, namely Potential and Kinetic.

Potential Energy, or stored up capacity for work, is possessed by a raised body by virtue of the fact that it can perform work while it is descending. Hence reservoirs are built on mountain sides to trap the potential energy of the water so that it can be used under controlled conditions to drive water turbines as it descends through pipe lines to lower levels.

Kinetic Energy is possessed by a body in motion by virtue of the fact that it must give up energy in coming to rest.

Conservation of Energy. Energy cannot be created or destroyed but can be converted from one form into another. This law is known as the Conservation of Energy and is for all practical purposes true except that the nuclear physicist in splitting the atom has succeeded in converting mass into energy.

Fig. 56 illustrates a pile driver. Consider a "monkey" weighing W lb. at h ft. above the head of the pile. In hauling the weight this distance it is necessary to impart W × h ft.-lb. of potential energy. Upon release it falls the same distance and on impact imparts Wh ft.-lb. of energy to the pile. From the equations of motion

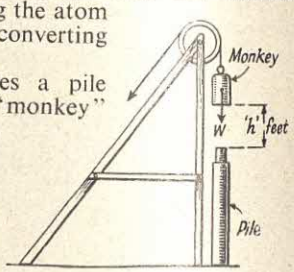


Fig. 56. Pile driver employs potential and kinetic energies.

$$v^2 = u^2 + 2gh$$

$$\text{as in this case } u = 0,\ v^2 = 2gh$$

$$\therefore h = \frac{v^2}{2g}$$

From the law of conservation of energy the kinetic energy at moment of impact on the pile must equal the initial Potential energy of the monkey. Thus :

$$\textit{Kinetic Energy} = W \times h = \frac{Wv^2}{2g}$$

Definition of " Power "

Power is defined as the *rate* at which work can be done, and the greater the source of energy the greater is the amount of work that can be done in the same time. The unit of power must therefore include a time factor such as foot-pounds *per second*, or inch-tons *per hour*, etc. It has been estimated that an average horse can do an amount of work in one minute equivalent to lifting 22,000 lb. through 1 foot, or 22,000 ft.-lb. per min. This very arbitrary figure has been increased to 33,000, and this value has been accepted. The unit of power then is called *one horse power* and represents 33,000 ft.-lb. of work per minute. It is important to notice that an engine capable of developing, say, 14 horse power, and described as a 14 H.P. engine, can develop 14 × 33,000 ft.-lb. of work *every minute*, so that in one hour its output has been 14 × 33,000 × 60 ft.-lb. and, working continuously for one day, 14 × 33,000 × 60 × 24 ft.-lb. of work are expended. Similarly, of course, 1 horse power equals 550 ft.-lb. per second.

EXERCISES

(1) A block of granite weighs 1 ton and the coefficient of kinetic friction between it and the ground is 0·6. Calculate the horizontal force necessary to move it at constant velocity.

(2) A box weighing 1 cwt. is sliding at a uniform velocity down a chute which is inclined at an angle of 14° 2′ to the horizontal. If the chute is lowered into a horizontal position, what force would be necessary to keep the box sliding at a uniform speed?

(3) A capstan winch is hauling a truck weighing 10 tons. The coefficient of friction between the wheels and the rails is 0·02. What work has been exerted when the truck has been moved 30 ft. ?

(4) A bricklayer's mate climbs a ladder to reach a platform 30 ft. above the ground. His weight is 10 stone and he carries a hod and bricks totalling 70 lb. How much energy has he expended when he reaches the top ?

(5) A boy runs up a flight of stairs, 60 in number, in 12 secs. The rise of each stair is 8 inches. What horse power is he exerting ? The weight of the boy is 8 stone.

(6) A motor car drives along a level horizontal road at 40 miles per hour against a total resistance of 50 lb. What is the horse power of the car ?

(7) A 100-lb. weight is used to drive a reinforced concrete pile into the ground. The weight is raised 10 ft. above the pile and then released. Calculate the kinetic energy of the weight when it reaches the head of the pile.

(8) A railway coach of 20 tons weight is running into a siding at a uniform speed of 2 miles per hour and is brought to rest by spring buffers which compress 6 inches in the process. What is the average resisting force of the springs assuming they absorb all energy ?

ANSWERS TO EXERCISES IN LESSON 8

(1) 2·49 secs. and 124·5 ft. (2) 2,300 ft./sec.
(3) 28 lb.
(4) 8,000 poundals or 248 lb. wt.
(5) 5 tons. (6) 0·67 ft./sec. (7) 260 lb. ft.

LESSON 10

Theory of Simple Machines

A MACHINE is a contrivance designed for the purpose of taking in energy in some form, modifying it, and delivering it in some other form more convenient for the purpose in view. The force which applies energy at one point is called the *effort* and the force delivered at another point overcomes the *resistance* or the *load.*

For example, geared winches, chain or rope blocks, a crow-bar, etc., are instances of machines designed to enable man to lift, or apply, far greater loads than can be supported by the human frame. Conversely, the bicycle is an example of a machine in which the velocity is increased (the rim of the wheel moves much more rapidly than the pedal) but the force is reduced. The mechanism that connects the engine to the driving wheels of a car is another example. Not only do the wheels rotate more slowly than the engine but, should the load on the engine become too great, by the driver changing to a lower gear the wheels can be made to rotate even more slowly relative to the engine and the load on the engine is thereby reduced.

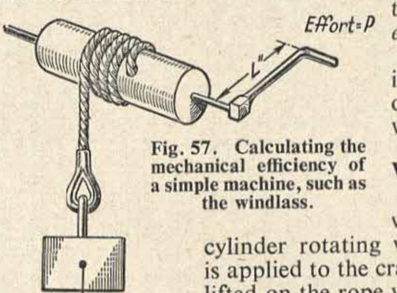


Fig. 57. Calculating the mechanical efficiency of a simple machine, such as the windlass.

In all these cases it should be observed that no more energy can be obtained from the machine than is put into the machine ; in actual fact, because of the friction of the moving parts which absorb energy in the form of wasteful heat and noise the output is less than the input. Throughout the ages people (without studying the principles involved) have tried to design a machine capable of producing perpetual motion, but from what has just been stated it is quite impossible to achieve such a result unless perpetual energy, in one form or another, is supplied.

Some Basic Definitions

In all machines there are three terms in use which need some explanation.

Velocity Ratio (V.R.) is the ratio of the distance moved through by the *effort* compared with the distance moved through by the *load* in the same time.

Mechanical Advantage (M.A.) is the ratio of the *load* overcome and the *effort* applied to overcome it.

Mechanical Efficiency (η, *eta*) is the ratio of the work got out of the machine compared with the work put into it.

Windlass

Fig. 57 shows a simple windlass, consisting of a cylinder rotating with an axle. The effort P is applied to the crank handle and the load W is lifted on the rope wound round the drum.

The crank's length is L inches and the mean radius of the drum and the rope (measured to the centre of the rope) is *r* inches. If the crank handle is given one revolution, then the distance moved by the effort P is the circumference of a circle traced out by the handle and is equal to 2πL inches. At the same time the rope supporting the load W winds one turn round the drum, equal to $2\pi r$ inches, which is of course the amount that W rises. The Velocity Ratio is therefore

$$\text{V.R.} = \frac{\text{Distance moved by effort P}}{\text{Distance moved by load W}} = \frac{2\pi \text{L}}{2\pi \text{l}} = \frac{\text{L}}{r}$$

The mechanical advantage, by definition, is :

$$\frac{W}{P}$$

and the mechanical efficiency is

$$\frac{\text{Work got out}}{\text{Work put in}} = \frac{W \times \text{Distance moved by W}}{P \times \text{Distance moved by P}}$$

$$= \text{M.A.} \times \frac{1}{\text{V.R.}} = \frac{\text{M.A.}}{\text{V.R.}}$$

therefore, $\text{Efficiency} = \frac{\text{M.A.}}{\text{V.R.}}$

or, $\text{Efficiency} \times \text{V.R.} = \text{M.A.}$

or, $\text{Efficiency} \times \text{V.R.} \times P = W.$

This is the fundamental equation for all machines. It will be noticed that if the machine is frictionless (an impossible condition in practice), then the efficiency will be 100 per cent. or unity, and then

Velocity Ratio = Mechanical Advantage.

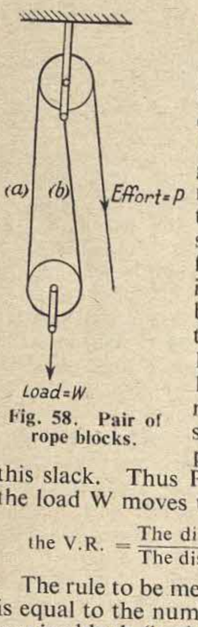


Fig. 58. Pair of rope blocks.

Rope Blocks

A very useful form of machine for lifting is the pair of rope blocks, a simple example of which is shown in Fig. 58, consisting of a pulley, grooved to accommodate the rope top and bottom, with the rope threaded round as shown. The problem is to find the V.R. value first; this is best considered by grasping both ropes *a* and *b* and lifting the bottom block bodily, say, 1 ft. Then W has been raised 1 ft., and now there are two ropes *a* and *b* each having 1 ft. slack, so that P must be pulled down 2 ft. to take up this slack. Thus P moves through 2 ft., while the load W moves through 1 ft., and therefore

$$\text{the V.R.} = \frac{\text{The distance moved by P}}{\text{The distance moved by W}} = \frac{2}{1} = 2.$$

The rule to be memorised here is that the V.R. is equal to the number of ropes to and from the *moving* block (in this case 2) and it is also equal to the number of pulleys in the system (in this case 2).

Triple and Differential Blocks

Fig. 59 shows a system of pulley blocks containing 3 sheaves in the top and 3 sheaves in the bottom blocks. The sketch is diagrammatic, but actually all the sheaves in each block are on the same spindle side by side. Once more, if W is lifted bodily 1 ft., then there are 6 loose ropes *a, b, c, d, e, f*, each having 1 ft. of play, or slack, and so P must be pulled through 6 ft. in order to take this slack up, and therefore V.R. equals 6, which is also the number of ropes to and from the moving block and is also the number of pulleys in the system as before.

Fig. 60 illustrates an ingenious variation of the pulley system, known as Weston's Differential Block. It consists of two sheaves in the upper frame mounted solidly together, one slightly smaller in diameter than the other, and a free pulley at the lower end. The top wheels have teeth formed in their rims to accommodate the links of the endless chain which is threaded round as shown, so that when the chain is pulled round no slipping can occur at the top sheaves. If the large pulley in the top has a diameter of D inches and the smaller pulley a diameter of *d* inches, then when the effort P is applied and the two sheaves together make one revolution, the portion of the chain marked *a* moves up and around the big pulley a distance equal to its circumference πD inches, and at the same time a portion of the chain marked *b* unwinds off the smaller pulley an amount equal to its circumference πd inches. The net shortening of the chain *a* and *b* is therefore

$\pi D - \pi d$, and it follows that the load W rises just half this amount,

or $\frac{\pi D - \pi d}{2}$.

$$\text{So that the Velocity Ratio} = \frac{\text{Distance moved by P}}{\text{Distance moved by W}}$$

$$= \frac{\pi D}{\frac{\pi D - \pi d}{2}} = \frac{2\pi D}{\pi(D - d)}$$

$$= \frac{2D}{D - d}.$$

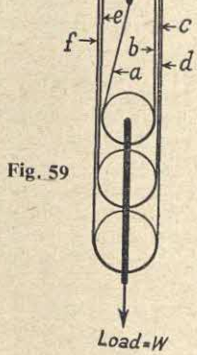


Fig. 59

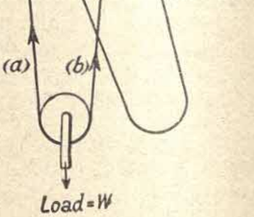


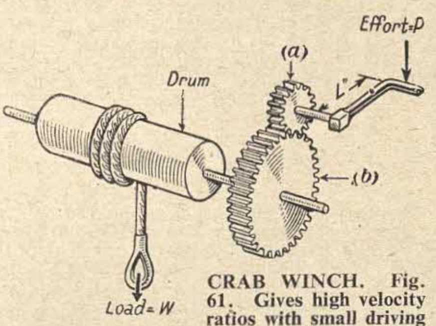
Fig. 60

Fig. 59. Triple pulley blocks in diagram. Mechanical advantage obtained is in proportion to velocity ratio less friction loss. Fig. 60. Differential pulley blocks make use of high friction factor.

Since the circumference of each of the top two sheaves is proportional to their diameters, and also the number of teeth in each circumference is proportional to the circumferences, it follows that the Velocity Ratio can also be expressed as:

$$\frac{2 \times \text{the no. of teeth in the big sheave}}{\text{The difference in the no. of teeth in each wheel.}}$$

It will be at once apparent that there must be an exact number of teeth in each wheel, and so the smallest difference must be 1, and this gives the maximum Velocity Ratio. In practice the wheels are designed with one more tooth space in the larger wheel than in the smaller. The friction in this type of machine is very high, and consequently the Mechanical Efficiency is always less than 50 per cent., and so the machine will not "overhaul," or "run back" when the effort P is relaxed. In other words, the load W can be lifted to any height and then left suspended at that height by simply removing the effort P.



CRAB WINCH. Fig. 61. Gives high velocity ratios with small driving pinion.

Crab Winch and Screw-Jack

Fig. 61 is a diagrammatic sketch of a single geared crab winch operated by a hand crank in which high velocity ratios can be obtained by making the driving pinion *a* small in comparison with the driven wheel *b*. When the effort P makes the crank handle turn one revolution, then the distance moved by P is $2\pi L$ inches where L is the length of the crank. The wheel *a* makes one revolution, and wheel *b* makes a fraction of one revolution equal to the ratio of

$$\frac{\text{the no. of teeth in } a}{\text{the no. of teeth in } b} = \frac{Na}{Nb}$$

and the rope supporting the load W therefore winds up this fraction of the circumference of the drum plus the thickness of the rope. If the mean radius of the drum and rope, measured to the centre of the rope, is *r*, then the fraction that W rises will be

$$\frac{Na}{Nb} \times 2\pi r.$$

The Velocity Ratio then is :

$$\text{V.R.} = \frac{\text{Distance moved by P}}{\text{Distance moved by W}} = \frac{2\pi L}{\frac{Na \times 2\pi r}{Nb}} = \frac{L}{r} \times \frac{Nb}{Na}$$

Fig. 62 shows a simple screw-jack for lifting the road wheels of a car off the ground. It consists of a cast iron "bottle," fitted in the neck of which is a toothed bevel wheel free to rotate. An internal square thread is cut in this wheel, and the wheel is driven round by a smaller bevel-toothed pinion into which a square bar can be fitted, at the other end of which a wooden handle can be inserted to provide the torque. A square threaded spindle fitted at the top end with a swivel bracket screws into the large bevel wheel and is provided with a flat side to prevent it from rotating within the "bottle." When this bevel wheel makes one revolution the spindle rises vertically the pitch of one thread *p*. For one complete turn of the wooden handle, length L inches, the effort P, in this case shared between the two ends, moves through a distance of πL inches and the large bevel wheel rotates a fraction of one revolution equal to the ratio of

$$\frac{\text{the no. of teeth in } b}{\text{the no. of teeth in } a} = \frac{Nb}{Na}$$

and therefore the spindle supporting load W rises this fraction of the pitch *p* of the thread, so that the Velocity Ratio is :

$$\text{V.R.} = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}} = \frac{\pi L}{\frac{Nb \times p}{Na}} = \frac{\pi L}{p} \times \frac{Na}{Nb}$$

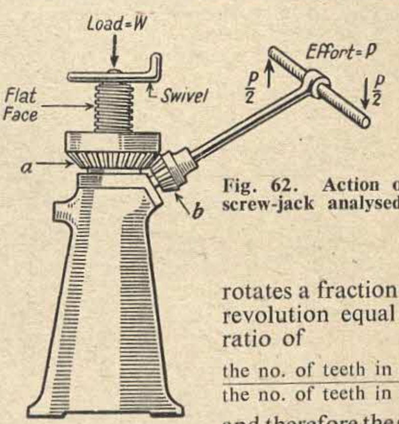


Fig. 62. Action of screw-jack analysed.

EXERCISES

(1) A pair of rope blocks has 2 sheaves in the top block, 1 in the bottom. Sketch the arrangement, and calculate the velocity ratio. If the efficiency is 75 per cent., what effort is required to lift half a ton?

(2) Sketch an arrangement of pulley blocks having 3 sheaves in the top and 2 in the bottom block. If an effort of 5 lb. will lift 20 lb., what are the mechanical advantage, the velocity ratio, and the mechanical efficiency?

(3) A set of Weston's Differential Pulley blocks has 12 teeth in the large wheel, 11 in the small, and an effort of 24 lb. will lift 96 lb. Calculate the velocity ratio,

the mechanical advantage, and the mechanical efficiency.

(4) Find the number of teeth required in the large wheel of a single geared hand-operated crab winch so that an effort of 10 lb. will lift a weight of 210 lb. if the small pinion has 20 teeth, the length of the crank is 12 inches, and the mean diameter of the drum and rope is 4 inches. The efficiency of the machine is 70 per cent.

(5) A screw-jack as shown in Fig. 62 is used to lift a weight of 3 cwt. There are 18 teeth in the large bevel, 10 teeth in the small bevel, and there are 5 threads per inch on the spindle. If the efficiency of the jack is 20 per cent., what is the effort required at the handle which has a length of 12 inches ?

ANSWERS TO EXERCISES IN LESSON 9

(1) 1,344 lb.
(2) 28 lb.
(3) 13,440 ft.-lb.
(4) 6,300 ft.-lb.
(5) 0·6787 h.p.
(6) 5·33 h.p.
(7) 1,000 ft.-lb.
(8) 11,950 lb. wt.

ANSWERS TO EXERCISES IN LESSON 10

(1) V.R. = 3. Effort = 497·8 lb.
(2) M.A. = 4, V.R. = 5, η = 80 per cent.
(3) M.A. = 4, V.R. = 24, η = 16·67 per cent.
(4) 100 teeth.
(5) 2·48 lb. at each end of handle.

BOOK LIST

Elementary. *Elementary Mechanics with Hydrostatics*, D. Humphrey and E. A. Baggott (Longmans Green) ; *Elementary Mechanics*, S. G. Goodwill (O.U.P.) ; *Mechanics for Beginners*, I. Todhunter (Macmillan) ; *Elementary Mechanics*, Sir Oliver Lodge (Chambers) ; *Mechanics and Hydrostatics for Beginners*, S. L. Loney (C.U.P.).

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HISTORY
Ancient & Medieval

DIVIDED *into two sections, as indicated by its title, this Course begins with recorded history as disclosed in Ancient Egypt and it covers all the empires, kingdoms, and peoples of the ancient world. Medieval History, arbitrarily but conveniently considered as beginning with the fall of the Roman Empire in* A.D. 476, *is concerned with the Old World for a thousand years until the discovery of America by Columbus in* 1492.

From that point the reader will continue with the following Course on MODERN HISTORY *which records world events in brief up to the present day. In Volume* 5 *is an expanded treatment of* BRITISH HISTORY *from the arrival of the Romans. Other Courses of importance to the student of history are* SOCIAL HISTORY *in Volume* 4 *and* ARCHAEOLOGY *in Volume* 3.

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LESSON 1

The Beginnings of History

In these volumes history is divided into four courses : Ancient and Medieval ; Modern, beginning with the Reformation ; British, from pre-Roman days to the Second World War ; and Social, devoted to the life and activities of ordinary people through the ages.

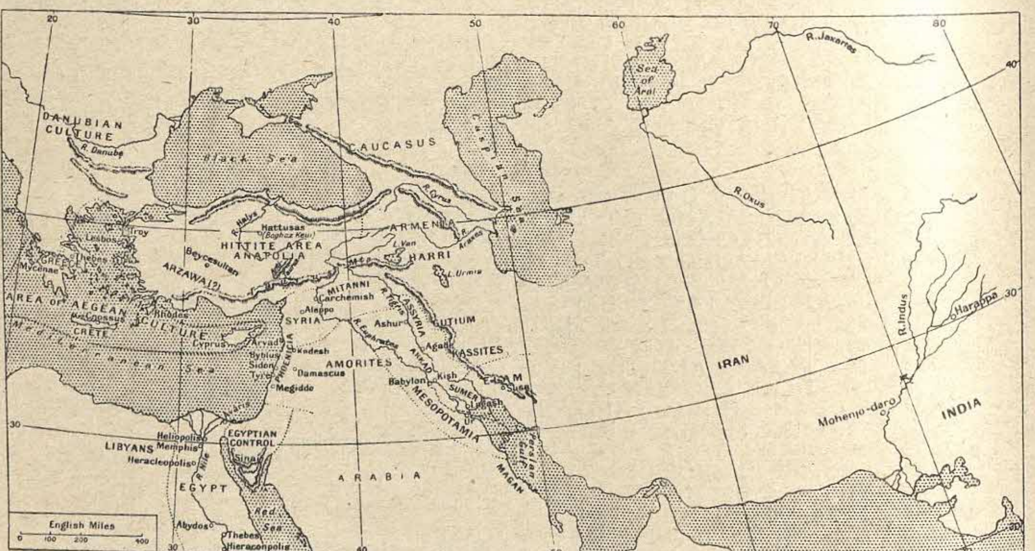
In this present Course history is studied as the collective action of organized communities from the beginnings of recorded time ; these beginnings have been pushed far back, beyond the earliest use of writing, by the analysis of legends and the evidence of archaeological discovery. Organized communities are known to have existed in the Nile basin nearly six thousand years ago. For the first half of that period the records are meagre but they form the beginnings of "ancient" history, which may by common consent be said to extend to the disruption of the Roman empire in the 5th century of the Christian era.

This introductory Lesson is concerned with the conditions which gave birth to early civilizations. In consideration of civilization as a whole it must be remembered that there is no certainty of progress. Communities may lose their vitality, and then progress ceases. Fighting barbarians may overthrow once vigorous peoples who have forgotten how to fight, and recovery may be delayed for centuries. The value of history lies in the hope that man, accumulating experience, will improve his condition by acting upon what he has learnt. For any such improvement to be made and sustained it is not enough to know what has happened ; man must also try to relate events to their causes.

Early Groups of Mankind

The earliest distinguishable peoples or groups of peoples appear in the area which had its twin centres on the Nile and the Euphrates ; they have been called the Mediterranean and the Semitic ; on the lower Euphrates was a people called the Sumerians, who were of Mongolian type. Behind the mountains on the north and west were peoples who may conveniently be called Armenian or Armenoid ; they come on the scene as Hittites about 2000 B.C. At the same time in the eastern mountains there are signs of the first Aryan or Indo-European migrations ; one branch of this fifth group was already making its way into India.

But it is no longer considered scientific to speak of basic Aryan or Semitic *races* ; in Europe or Asia moving peoples have mixed for long ages, sometimes imposing their languages, sometimes learning others, in their new homes. The terms Aryan and Semitic are now restricted to *groups of languages*, each spoken at various times by peoples of different racial types. Thus



THE FERTILE CRESCENT AND THE INDUS VALLEY. The cradle-lands of the world's earliest organized communities. These names and boundaries are necessary for the understanding of ancient history down to c. 1573 B.C., but they were not all as shown here at any particular moment.

these terms cannot be used as divisions of existing white peoples.

Between 2000 and 1000 B.C., if not earlier, other Indo-European tribes were moving westward to form the earliest historical European peoples. One collection, the Phrygian, having crossed the lower Danube struck into Asia Minor; another, the Hellenic, poured into the Balkan peninsula; a third, the Latin, went farther afield into Italy; a fourth, the Celts, whom the Romans called Galli, or Gauls, went on till they reached the Atlantic, and spread north into Britain, south into Spain, and later into Italy in rear of the Latins. About a hundred years before the Christian era the Teutonic or Germanic and Scandinavian peoples were first noticed by writers of Greek and Latin civilizations. All these Indo-European peoples, differing widely from each other, had languages, beliefs, and institutions suggesting a common origin in the remote past. The Indo-European tribes were nomads or wanderers for centuries after the rise of the first organized communities entitled to be called states. These came into being in the two great river basins where soil and climatic conditions favoured agricultural settlement, and where pasture was available without constant movement. Those who first learnt to substitute metal for stone implements enjoyed a great advantage over their competitors; the hardening of copper into bronze by the admixture of tin was another advance; even more important was the substitution of iron for bronze. Mesopotamia and Egypt led the way in the use of metals, and gained a long start in the development of civilization.

The first records were either monumental, in the shape of representational or symbolical carvings on stone, or traditional, consisting of stories and legends passed down from generation to generation. Such legends were most readily remembered when embodied in ballads or poems, sometimes later incorporated into a national epic such as the *Iliad* of Homer, first elaborated by minstrels and story-tellers and at length preserved by being written down. These legends may provide a faithful record of manners and customs but cannot be relied on as history, although archaeological evidence may prove them to be based on fact. Monumental carvings supply much more accurate information; of these immense numbers have been revealed by the excavations of archaeologists.

CARVEN HISTORY. In Mesopotamia, Naram-Sin triumphs over his foes.
From J. de Morgan, Fouilles à Suse.

LESSON 2

The Pharaohs who Founded Egypt's Greatness

The Nile valley may be divided into three geographical areas. The southern area is the Upper Nile, ending about the first—that is, most southerly—cataract; the northern or Lower Nile includes the Delta, but extends for a short distance above its apex; the third area is the middle region between the first cataract and the Delta. The middle region is Upper Egypt, the Delta is Lower Egypt; the country above or south of the cataracts, the area of the Upper Nile, is outside Egypt, and is not to be confused with Upper Egypt. Upper and Lower Egypt were settled by peoples engaged in agriculture, with some form of government, long before 4000 B.C. There are signs of antagonism between the peoples of the two areas; the main stock in both was Mediterranean, but the Delta contained a considerable Semitic mixture. The gods of Lower Egypt were not those of Upper Egypt.

The history of this very early period was first derived from traditions collected by the Greek Herodotus in the 5th century B.C., and from those compiled by the Egyptian Manetho in the 3rd century B.C. Manetho's work was more valuable, because he had more temple records to consult. Modern Egyptologists are much better interpreters of very ancient records than Egyptian scholars were, but on the whole Manetho's accounts correspond remarkably well with those on the ancient monuments.

Some time in the fourth millennium B.C. arose the Ist dynasty of kings, or pharaohs, who ruled both Upper and Lower Egypt. The dynasty belonged to Upper Egypt, where kings were supposed to be incarnations of the great god Horus, who was symbolised by the figure of a hawk. The traditional founder of the dynasty was called Menes by the Egyptians to whom Herodotus talked about 460 B.C.; Menes is probably a name or title which covers two or three real men. It was probably about this time that metals were first worked; perhaps their copper weapons enabled the Upper Egyptians to dominate the Delta. The fact of such a conquest points to the existence in Upper Egypt of a long-established monarchical form of government.

DIVINE PARENT OF PHARAOHS. Originally the sun god of northern Egypt, Ra came to be regarded as actual father of the Egyptian monarchs.
Berlin Museum

Names of actual Ist dynasty kings have been recovered from their tombs—Narmer, Hor-Aha, Zer, Uadji, Udimu, Ka'a—and signs of burning in the massive stone structures suggest that their successors of the IInd dynasty were their enemies, probably from Lower Egypt, who came to power about 3000 B.C.

A third dynasty was founded by the marriage of the heiress of the IInd dynasty to an Upper Egyptian chief. With this king the supremacy returned to Upper Egypt; his son Tjeser or Zoser built the first of the pyramids and moved the capital to Memphis in Lower Egypt. The dynasty ends with Sneferu, whose son (or other relative) Khufu, second king of the IVth dynasty, built the Great Pyramid at Gizeh. His successors Khafra and Menkaura each built another; these three kings are better known by the Greek forms of their names—Cheops, Chephren, and Mycerinus.

The building of the pyramids gives evidence of advanced mathematical knowledge, though not of very advanced mechanical appliances. The Egyptians quarried these great blocks of stone, shaped them, hauled them by hand over great distances, and raised them layer by layer. The expenditure of labour is almost incalculable: the stone in the Great Pyramid would suffice to build a wall three feet high and one foot thick all round France. At this period, also, the Egyptians had already attained to perhaps their highest standard of sculpture. Lower Egypt, containing the capital city, apparently had under the IIIrd dynasty a more advanced civilization. By the time the pyramid builders were succeeded by the Vth dynasty, Lower Egypt was certainly more important; the southern sun god Horus had become identified with the northern sun god Ra, but from this time his most prominent attributes are those peculiar not to Horus but to Ra.

Under the first four dynasties the pharaohs were supreme, but during the Vth dynasty a king came to the throne while still a child. The result was that in the reign of this pharaoh, Pepi, the governors of the Egyptian districts,

THE PYRAMID BUILDERS. Zoser or Tjeser, who reigned during the Third Dynasty, built the first pyramid (shown above). Khufu or Cheops (right) built the Great Pyramid.

or *nomes*, developed into a powerful aristocracy. Each ruled his nome without much attention to the king, who failed to establish supremacy in middle life, and reigned—tradition says for 94 years—as a nonentity.

From the Vth to the IXth dynasties Egypt was broken up into a number of almost independent principalities, whose lords merely professed allegiance to one sovereign. The IXth and Xth dynasties made efforts to unite the country from a new capital called by the Greeks Herakleopolis, 60 miles north of Memphis. Its supremacy was ended by the founder of the XIth dynasty, a noble of the Thebaid, the northern region of Upper Egypt.

The XIth dynasty established a powerful government ; the arts of sculptor and temple-builder made a great recovery after centuries of political disorder. These rulers prepared the way for the great pharaohs of the XIIth dynasty, the Amenemhets and Senusrets. The former name emphasises the supremacy of the Thebaid, where the supreme deity was called Amen. The kings of this dynasty were builders, engineers, conquerors, and organizers of a strong political system.

Legends of conquest are attached to the name of one of the Senusrets, whom the Greeks later called Sesostris. His successor, Amenemhet III (some time between 2000 and 1800 B.C.), carried out great works to control the waters of the Nile, and transformed the lake of Moeris into a reservoir. After him the power of the government fell away again, and, perhaps in the 18th century B.C., was altogether broken up by the great invasion of the Semitic shepherd kings, or Hyksos.

AMENEMHET III, one of Egypt's most enlightened rulers, carried out irrigation works.

LESSON 3

The Semites from Hammurabi to the Hebrews

DURING the two thousand or more years of Egyptian history outlined in the Second Lesson another civilization was reaching a high stage of development in the great river basin of the Tigris and Euphrates in western Asia.

Five or six thousand years ago the Persian Gulf extended a couple of hundred miles farther up this basin than it does at the present day. Asiatic history, as at present understood, begins within an area, roughly speaking, a hundred miles wide, extending inland two hundred miles from the head of the Persian Gulf. The earliest actual records date from near the close of the fourth millennium, about the time when Sneferu was building his pyramids. There were cities and temples in those days, and the first king dedicated a vase in the city of Nippur. The region comprised two divisions, the lower known as Sumer, the upper as Akkad. The Sumerians were Mongols ; the Akkadians were, at any rate in part, Semites ; and it is curious to observe that the Sumerians represented their own gods as of the Semitic type—bearded, not smooth and shaven like their own kings.

CUNEIFORM SCRIPT. Tablet covered with temple accounts in this early form of writing.

The city states of Sumer and Akkad, ruled by kings, made war upon each other and against the Elamites in the mountains beyond the Tigris. By 3000 B.C. the Sumerians were not only carving pictures but had invented a script or system of writing on stone or clay which is called *cuneiform*, the various sounds being represented by letters composed of wedge shapes (Latin *cuneus*, a wedge). They used bronze, and had learnt to construct canals. It is possible that some of them migrated eastwards and laid the foundations of the Chinese Empire ; there are also evidences (seals, for instance) of connexion between Sumer and the earliest civilization in the valley of the Indus.

Various cities in Sumer and Akkad achieved a temporary supremacy ; a king of Umma led presumably victorious armies as far as the Mediterranean. Some time between 2700 and 2500 B.C. Shargani ruled in Akkad ; he was the original of the partly mythical hero Sargon, the traditional founder of the Semitic power in Mesopotamia, concerning whom many legends arose. After Shargani, who united Sumer and Akkad, his grandson Naram Sin conquered surrounding peoples ; his victories are recorded on monuments now at Paris. After Naram Sin records are scanty for a long time.

HAMMURABI. Sculpture of the great lawgiver of the 21st century B.C.

About the 21st century B.C. a Semitic-speaking people, the Amorites, or Westlanders, seem to have moved into Mesopotamia by way of the Upper Euphrates. Advancing eastwards down the river they set up a dynasty in the hitherto unimportant city of Babylon. Their greatest king was Hammurabi, who began to rule about 2100 B.C.

Babylonia was now in an advanced stage of civilization. Hammurabi codified the laws and engraved them on stone. They are elaborate laws, detailing the rights of slaves and women, debtors and creditors, landlords and tenants, orphans and widows, and regulating the transfer of land, water supply, and use of a silver standard of exchange.

Hammurabi's dispatches to his officers, and a variety of legal documents, survive in the form of clay tablets.

Hammurabi's Reign

At the beginning of Hammurabi's rule Sumer was under Elamite dominion ; Chedorlaomer of Elam is known from the Biblical narrative as the head of the confederacy which attacked Sodom and Gomorrah, the "cities of the plain," and captured Abraham's nephew Lot, whom Abraham rescued. A little later Hammurabi (who is generally identified with the Amraphel of Shinar mentioned in Genesis) seems to have asserted himself and to have become the most powerful of the allied or warring kings in Mesopotamia and the neighbouring lands.

Whatever obscure movements of peoples lie behind the story of Abraham, it appears that at about this time other tribes with Semitic speech took possession of the coastland, that is to say Palestine and Phoenicia, and founded the Phoenician cities. Hammurabi was perhaps a king of the type of Alfred the Great, a bold and skilful warrior and conqueror, even more famous as an organizer and administrator. He founded a dynasty which reigned for some generations and disappeared in the century of the Hyksos conquest of Egypt.

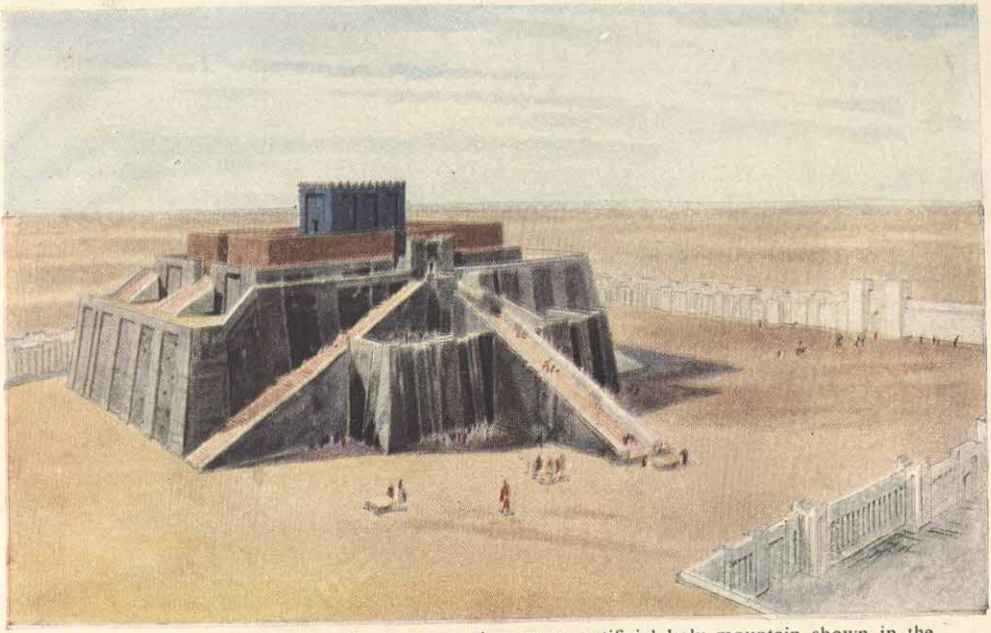
Some time after the death of Hammurabi, the Hittites, or Khatti, whose king, Tidal, had been an ally of Chedorlaomer and Hammurabi, made a great raid out of the north-western mountains into Mesopotamia ; almost immediately afterwards there appeared from the east a quite different people, the Kassites.

Kassite Dynasty

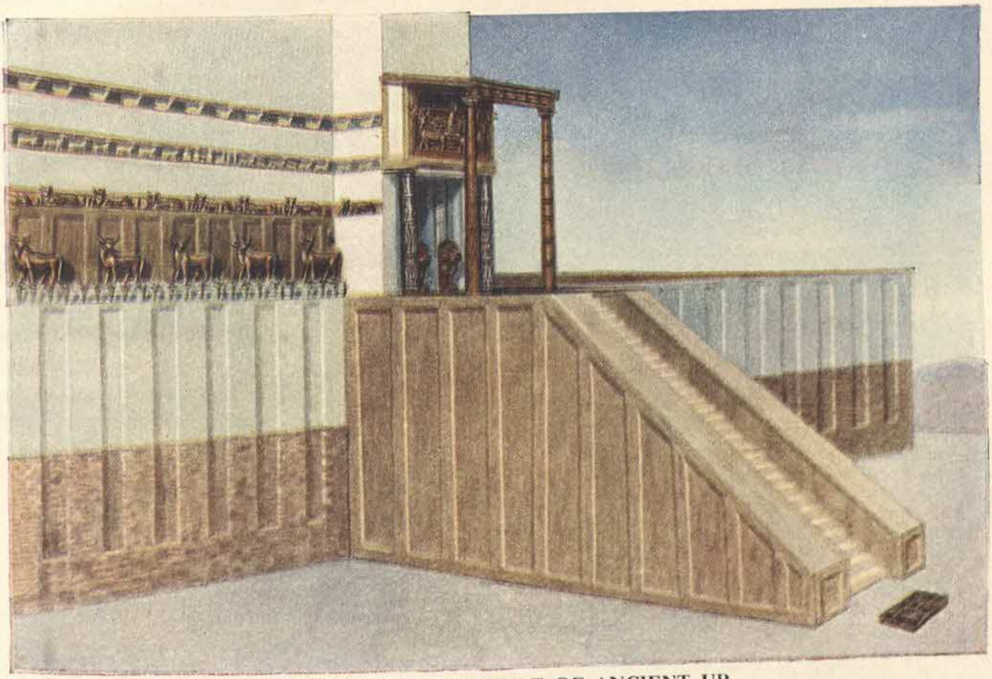
The Kassites were probably Iranian "Aryans," who broke into Sumer through the Elamite mountains, and established a Kassite dynasty in Babylon, where its kings ruled for several centuries without dispossessing the early populations. Another "Aryan" group seems to have struck into Upper Mesopotamia from the north-east, and to have established an overlordship, again without dispossessing the previous population, in what was called the kingdom of Mitanni. These invasions may be dated at about 1700 B.C., when the Hyksos were already in Egypt. Apparently a confederation of nomadic "Semitic" tribes from Arabia, they broke into Egypt about 1800 B.C. and conquered the Delta, ruled as overlords, and tried without much success to extend their dominion over Upper Egypt. Presumably in the time of this conquest the Israelite clan or clans settled in Egypt. The victory of the Hyksos may have been chiefly due to their use of cavalry and war-chariots, previously unknown in Egypt. They ruled as foreign conquerors, not mixing with the natives.

The Egyptian dynasties numbered from XIII to XVII, which were probably partly contemporary with each other, belong to this period. Some of them were subject to the Hyksos kings, and towards the end of the 17th century B.C. the chiefs of the Thebaid or district around Thebes, who appear as the XVIIth dynasty, were making desperate efforts to drive the Hyksos out. Early in the next century they succeeded, and about 1573 B.C. the liberator Aahmosi or Aahmes expelled the bulk of the foreigners ; it appears that at this time the Hebrews remained behind in a condition of slavery. Aahmes founded the XVIIIth dynasty, and the great period of the New Kingdom began.

HITTITE WARRIOR, shown on monument, with high hat and buskins.



Between 2400 and 2300 B.C. the immense ziggurat or artificial holy mountain shown in the illustration above was built by a king called Ur-Nammu or Ur-Eugur, at Ur in Sumer (later called Chaldea or Babylonia). The brick structure was surmounted by a temple of Nannar the Moon God. The Tower of Babel (i.e. Babylon) mentioned in the Bible was probably a ziggurat.



TEMPLE AND ZIGGURAT OF ANCIENT UR

Part of a temple at Al 'Ubaid, four miles from Ur, is shown in this lower reconstruction. Built between 3100 and 3000 B.C., at the time of the First Dynasty of Ur, the temple had wooden columns overlaid with copper or with incrustations of red and black stone and mother-of-pearl.

Reconstructions by Sir Leonard Woolley and F. G. Newton

LESSON 4

The Egyptian Empire in its Greatest Days

WHEN the Hyksos vanished from history and Egypt became the principal power, Babylonia was ruled by Kassites. Between Babylon and Mitanni was Ashur or Assyria, a country with a mixed highland people who became the most warlike nation of antiquity. Syria, Phoenicia, and Palestine held a number of petty states concerning which little is known except that the sea-going Phoenicians had already embarked upon their great commercial career. North of Syria and Mitanni was the powerful Hittite state or group of states, whose main strength lay beyond the Taurus mountains in the centre of Asia Minor. North-west Asia Minor was held by the Phrygian power whose history is dimly written in successive ruins on the mound of Troy. South-west, and perhaps also between Phrygia and the Hittites, lay the kingdom of Arzawa, the mound of whose capital city at Beycesultan near the head of the Meander river was first extensively explored in 1954.

EMPIRE BUILDER. Thothmes III, a brilliant general and astute statesman.

The New Kingdom

Aahmes and his successors Amenhotep I and Thothmes I were engaged in the reorganization of Egypt throughout the 16th century B.C. Thothmes was a warrior who carried his victorious arms as far as the Euphrates, and claimed sovereignty, without establishing the machinery of empire, beyond his own frontiers. Thothmes II was pharaoh for two or three years after the death of Thothmes I; then for the first 20 years of the 15th century B.C. Hatshepsut, daughter of Thothmes I, reigned in splendour as the first queen in history. To her succeeded her husband, Thothmes III, the maker of the first Egyptian Empire.

Thothmes, younger than his wife, had evidently been under her unwelcome control; his resentment is proved by his trying to obliterate her name from her monuments. His confidence in his own powers was completely justified. Hatshepsut was not warlike; Thothmes was no sooner alone on the throne when he began a series of campaigns to conquer Syria, where Hatshepsut had claimed only a nominal sovereignty. Details of those campaigns have been preserved, proving Thothmes to have been both a great strategist and a great tactician.

Marching through Palestine, he won a victory over the confederated Canaanites in the neighbourhood of Megiddo. This made the subjugation of Phoenicia comparatively easy; it was completed by an army transported by sea to the Phoenician coast. Thothmes proceeded to conquer northern Syria, and reached the Euphrates, though he did not cross it. The alarmed monarchs of Mitanni and Assyria sent him tribute; the Hittites sent him presents. He secured his dominion over western Asia by appointing Egyptian residents, or political officers, to see that his interests were served. Then he returned to Egypt and carried his conquest southwards, establishing control of the Upper Nile as high up as the Fourth Cataract. Thothmes ranks with the great conquerors; a general of genius, he was also the first statesman to assume responsibility for the countries he had conquered.

Akhnaton the Heretic

Two generations later Thothmes IV married a princess of Mitanni, the first foreign wife of a pharaoh. The son of this Thothmes was Amenhotep III, the great ruler whom the Greeks later called Memnon; two colossal statues of him at Thebes were famous not only for their size and dignity but also because for many years one of them "sang" at sunrise, probably as the result of some recurrent change of air temperature in fissures of the stone. Amenhotep III maintained peaceful relations with most of the surrounding kingdoms, dependent or free. The magnificent temples

TEMPLE BUILDER. Death-mask of Amenhotep III who built the Luxor and Karnak temples.

of Luxor and Karnak date from his reign, together with an immense artificial lake near Thebes.

This pharaoh married a Syrian princess ; their son was Amenhotep IV, in one respect the most remarkable of all the Egyptian kings, for he tried to replace the worship of the old gods by worship of a single deity whose symbol was Aton, the disc of the sun. He changed his own name to Akhnaton, and moved his capital to a new city, Akhetaton, whose site is now called Tell-el-Amarna. Absorbed in his unpopular attempt to transform the religious life of Egypt, Akhnaton took no care to maintain its military power, which in Syria declined and collapsed under pressure from the rising Hittite dominion. Akhnaton's immediate successors included Tutankhamen, whose name clearly indicates the blotting-out of the short-lived cult of Aton. The priests of Amen recovered power, the new capital was deserted, and Akhnaton was considered a heretic whose name must be defaced and forgotten.

DREAMER and HERETIC. Akhnaton tried to introduce the worship of a single god.

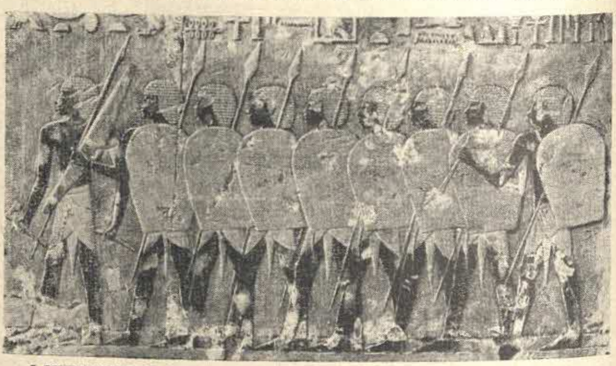
Posterity was not to be left without knowledge of Akhnaton. A quantity of official correspondence, dating chiefly from the first half of the 14th century B.C., was discovered in 1887, in the royal residence at Tell-el-Amarna. It had passed between Amenhotep III and Akhnaton and the kings of Mitanni, Assyria, Babylon, and the Hittites. The Kassite in Babylon ranked himself as the equal, if not the superior, of the pharaoh ; the Mitannian and the Assyrian both seemed to regard themselves, and to be regarded, as on a lower plane. The Hittite occupied a still lower but undefined position, being regarded as a formidable barbarian.

By the third quarter of the 14th century B.C., when Tutankhamen and his successor were on the throne of a disintegrating Egypt, the Hittites were absorbing Mitanni, pressing down upon Mesopotamia and gradually dominating Syria. The recovery of Egypt in the 14th century B.C. was the work of the founder of the XIXth dynasty, a noble named Horemheb, whose title rested on his personal merits and his marriage to a sister of Akhnaton's widow. His long work of reconstruction was carried on by Rameses I, a successor of his own choosing, and by Seti I, the son and colleague of Rameses. Twenty years later Seti was succeeded by Rameses II, the Great, the founder of what is known as the second Egyptian Empire, 1300 B.C. He campaigned in Palestine and Syria and against the Hittites, winning brilliant victories, and leaving an immense reputation which was, however, partly due to his practice of substituting his own name on monuments for those of famous predecessors. When he finally made peace with the Hittites, the recorded terms show that the advantage was by no means all on his side.

Decline of Egyptian and Hittite Power

Egypt needed government devoted to her internal development, not to foreign war. After the death of Rameses II she played no important part beyond her own borders, except

Courtesy of Egypt Exploration Society



LIFE UNDER THE EGYPTIAN EMPIRE. Left, representation of an Egyptian chariot on a stele from Tell-el-Amarna. It closely resembles actual specimens found in the tombs. Above, native infantry such as won Egypt her empire, armed with spear, battle-axe, and shield.

FOUNDER OF THE SECOND EMPIRE. **Rameses II, on the left in this mural, attempted great conquests in Asia; but the outward splendour of his reign hid a process of decay from which the Egyptian Empire never recovered.**

for a while under Rameses III, whose predecessor, Meneptah, is still by some authorities regarded as the pharaoh of the Hebrew Exodus. At the beginning of the 12th century B.C. a swarm of peoples from Asia Minor and the islands of the Aegean fell upon Phoenicia and Palestine, and threatened Egypt herself; but Rameses III, of the XXth dynasty, destroyed their fleet in the first great recorded sea-fight.

Egypt continued to enjoy a long period of material prosperity; the more shadowy Hittite empire, which had apparently crushed Arzawa to the west of it, went to pieces about the end of the 13th century B.C. No great catastrophe is indicated; whether or not the "peoples of the sea" were responsible, the Hittite dominion rapidly disappeared, and the Assyrian power to the south-east of it had the chance to develop. In the 13th century the Assyrian kings, with the help of a "Semitic party" in Babylon, ejected the Kassite dynasty. About the beginning of the 12th century B.C. Babylonians were once more ruling in Babylon.

LESSON 5

Rise and Fall of the Assyrian Empire

At the end of the 12th century B.C. Assyria emerged as a merciless conquering power under the warrior Tiglath Pileser I, who subjugated Babylonia, all Mesopotamia, northern Syria, and Phoenicia, and penetrated into Asia Minor. After 1100 B.C. Assyria seems to have experienced a set-back. About 1000 B.C., when the migration of Hellenic peoples was mixing or replacing the tribes already established around the Aegean, a new though minor power appeared in Palestine: the Hebrews. About the beginning of the 9th century B.C. Assyrian activity suddenly revived. From 893 B.C. onwards a systematic annual register of events was made, which has been preserved, so that dates can be fixed with certainty. Two vigorous kings reorganized the Assyrian monarchy; a third monarch, Ashurnasirpal, began a tremendous career of conquest and devastation. His armies crushed the mountain tribes of the upper Tigris, and swept round the "fertile crescent" to reach the Mediterranean and subjugate Phoenicia. The Assyrians were the most barbarous and destructive of early conquerors, especially in the maltreatment of prisoners and the annihilation or deportation of whole peoples. The sculpture on their palaces and temples is full of massacre and of the glorification of warring or lion-hunting kings.

After Ashurnasirpal came Shalmaneser, who repeatedly attacked Syria, where the king of Damascus, Benhadad, offered a surprisingly successful resistance, of which there are echoes in the Old Testament *Book of Kings*.

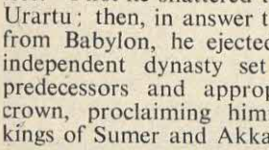
Well after the middle of the 9th century B.C., when Benhadad was dead, Shalmaneser conquered the greater part of Syria, though Damascus was not under firm control. He easily conquered Babylonia, where the merchants, reckoning that Assyrian protection of the trade routes was well worth paying for,

AN ASSYRIAN CONQUEROR. **Ashurnasirpal subjugated the mountain tribes of the Upper Tigris and the peoples of Phoenicia. In this relief he is shown crossing a river, seated in his chariot on a ferry boat.**

FORCED LABOUR UNDER SENNACHERIB. After his Egyptian expedition Sennacherib set about building Niniveh, using as workmen his captured foes. This bas-relief from Kuyunjik shows labourers, yoked like cattle, hauling timber.

supported him in ejecting the ruling dynasty. About the end of the century the resistance of Damascus finally broke down; but a new power, Urartu, growing in Armenia, was sufficiently threatening to keep Shalmaneser's less active successors engaged in the North.

In 745 B.C. the dynasty was deposed by a military commander who took the name of Tiglath Pileser IV. He reorganized the Assyrian armies and quickly reconquered the nations which had been hoping to shake themselves free. First he shattered the forces of Urartu; then, in answer to an appeal from Babylon, he ejected the semi-independent dynasty set up by his predecessors and appropriated the crown, proclaiming himself the heir of the kings of Sumer and Akkad. Seven years after his death another Sargon became king of Assyria.



PSAMMETICHUS I was appointed viceroy of Egypt by Ashurbanipal.

There had been revolts in the interval; Samaria made a desperate effort to break free. Sargon captured the city and deported some 30,000 of the population. Merodach Baladan, one of the ejected Babylonian dynasty, tried with the help of the Elamites to recover the crown. Sargon drove the Elamites back, but campaigning in the mountains of Elam was difficult; meanwhile southern Syria revolted again, encouraged by a king of Egypt. Sargon crushed another revolt in northern Syria, defeating the Egyptians in a great battle, struck again at Urartu, which had recovered some of its strength, and turned Merodach Baladan out of Babylonia, where again the commercial population preferred Assyrian rule.

At the end of the 8th century B.C. Sargon was succeeded by Sennacherib. In Egypt the XXth dynasty had given place to Libyan rulers, probably generals of the mercenaries who seized power in the Delta, while priest-kings held Thebes. One striking figure emerges from a long period of confusion—Sheshonk, the Shishak of the Bible, who founded the XXIIIrd dynasty and overran Palestine. An Ethiopian dynasty, the XXVth, united Egypt and fomented Syrian rebellion against Assyria.

EGYPTIAN CAPTIVES. Seventh-century Egyptians, taken prisoner by Ashurbanipal, are led away by their guards. Vast deportations of conquered peoples occurred under the Assyrians.

Sennacherib stamped out the revolt; Hezekiah of Judah bought him off, and saved Jerusalem from attack. Sennacherib was recalled to the north by renewed danger from the Elamites, who disputed possession of Babylon with him until in 689 B.C. he captured and burned the city. Then he turned on Egypt, but he had to raise his siege of Pelusium, the frontier fortress, because of plague among his army. This was probably the occasion when Jerusalem was also delivered by a pestilence in the Assyrian forces.

Esar-haddon and Ashurbanipal

Sennacherib was succeeded by Esar-haddon, a skilful soldier and statesman. By fighting and diplomacy he checked the Scythians and Medes, who were now pressing from the north-east, and another barbarian horde, the Cimmerians, who were ravaging Asia Minor and raiding into upper Assyria. Then he in his turn attacked Egypt, capturing Memphis in about 670 B.C. On his return to Assyria, he rebuilt Babylon, and tried to compose his central dominions by making one of his sons king of that city, and another son king in Nineveh.

The latter was Ashurbanipal, called Sardanapalus by the Greeks. Egypt was again in revolt ; Esar-haddon died on his way to deal with it. Ashurbanipal marched down and captured Thebes, deporting captives from other conquered countries to repopulate the devastated parts of the Nile valley. He also conquered Elam, but by so doing removed the barrier which had held the Medes and Persians from attacking Mesopotamia. Before his death, in 669 B.C., Egypt unostentatiously assumed independence ; the power of Assyria ended with this last mighty king. Nineveh, the Assyrian capital, was destroyed in 612 B.C. by Cyaxares the Mede.

Upon the ashes of Assyria rose the new Babylonian dominion of Nebuchadnezzar, a soldier who subdued all that had been the Assyrian empire before the time of Esar-haddon. He also constructed the gigantic fortifications of Babylon, and probably the celebrated Hanging Gardens. He carried off the bulk of the population of Judah into the Babylonish captivity from which they were released only when, after his death, the Persian Cyrus overthrew the new Babylonian empire and became lord of all western Asia.

LESSON 6

The Dawn of European History

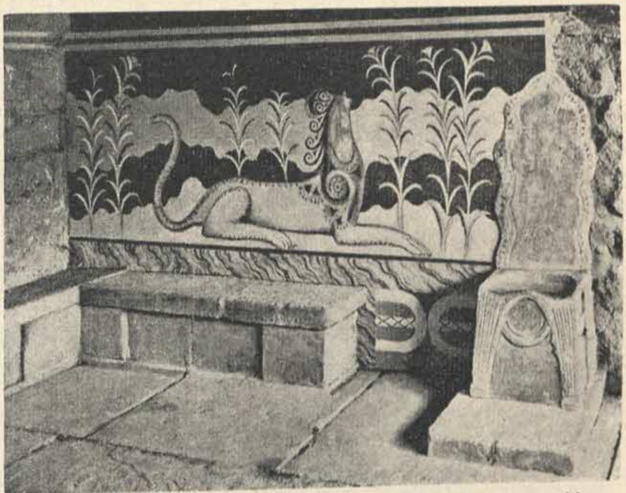
HITHERTO this Course has been concerned with the Oriental civilizations, kingdoms, and empires which rose and fell between 4000 B.C. and the middle of the 6th century B.C. —civilizations which lay within the area bounded on the north by the Taurus mountains and those of Armenia and Persia, with the Mediterranean as its western boundary, but embracing on the south-west the basin and delta of the Nile. Mention has been made of foreign peoples on the borders of this area, e.g. Elamites on the east and Hittites on the west. Civilizations next appear in the continent later called Europe ; the first of them spread from Crete to the Aegean islands and the mainland of Greece.

Among the foreigners recognizable in the fine paintings of Egyptian temples and tombs and palaces are the seafaring people known to history as the Minoans, who traded with Egypt even before the time of the Hyksos. Their first home was probably N. Africa ; they had occupied some of the Aegean islands, making their headquarters in Crete. They dominated the seas, developed a very advanced culture of their own, which owed something to Egypt, and—perhaps in the 14th or 13th century B.C.—planted outposts in the Peloponnesus (the modern Morea) at Tiryns and Mycenae. There, as well as at Cnossus, their capital in Crete, they left impressive monuments of their skill. Successive waves of Hellenic (i.e. Greek) invaders probably obliterated the formidable Minoan power not long after it had established itself at Mycenae.

The first recognizable state in Asia Minor was that of the Hittites, who emerge into history in the time of Hammurabi, sometimes invading western Mesopotamia, and figuring as one of the great powers in the time of the Amenhoteps and Rameses II. After that time the Hittite dominion crumbled away ; its end is obscure, like that of its western neighbour Arzawa ; the Phrygians may have contributed to the overthrow of both.

The Phrygians

The Hittites were perhaps only the most vigorous inhabitants of Asia Minor, or Anatolia, before Indo-European movements across the Bosporus began ; it has been suggested that Mitanni and the Kassites indicate a still earlier "Aryan" penetration of Mesopotamia from the east by peoples akin to the Iranians of Media



THE THRONE OF MINOS. This chair of white stone, with leaf-shaped back and hollow seat, was found in the palace of Cnossus. The fresco of gryphons and papyrus is a reconstruction.

and Persia. The Phrygians may have been another Aryan branch, related to the Hellenes and preceding them.

Crossing the Bosporus at an unknown date, they penetrated the north-west of Asia Minor, slowly conquering or mixing with the earlier population. Theirs was the city of Troy, which dominated trade through the entrance to the Euxine or Black Sea and finally perished about the beginning of the 12th century B.C. The Troy whose legends Homer immortalised was the seventh settlement on the same site. The first Troy may have been built long before the Phrygians crossed the straits into Asia.

The Achaeans

The fall of Homeric Troy (according to tradition, about 1200 B.C.) was perhaps an incident in the Hellenic expansion which brought about the overthrow of the central Minoan power, and was probably associated with that great southward movement of the "peoples of the sea" checked by Rameses III. Rameses, however, did not prevent the Philistines from establishing themselves in Canaan. While the Phrygians passed into Asia, the earliest Hellenes were overrunning the mainland of Greece and the destruction of Seventh Troy would seem to have been effected by Achaeans and Danaans, together with Argives from the Thessalian, not the Peloponnesian, Argos.

These are the names by which Homer calls the host which obliterated the Phrygian Troy, and Danaans are named as forming part of the pirate host defeated by Rameses III. Homer's warriors used bronze weapons ; iron he hardly mentioned. Like the Northmen some two thousand years later, they had taken to the sea ; the Egyptians learned to recruit from these sea rovers the mercenary troops on which they mainly relied after the 12th century. The Danaans and others may themselves have been dislodged from their mainland and island homes by the incursion of new Hellenic tribes from the north—the Dorians who brought the Age of Iron into Europe.

The Dorians

The Dorian conquest of, or predominance in, Greece was complete a century or two after the siege of Troy. The Dorian element was strongest in the Peloponnese ; some of the Achaeans and Danaans remained in Greece and the islands, others crossed to Asia Minor and founded the city states of Ionia. The famous Greek myths of the gods and legends of the heroes reflect folk-memories of the movements and wars of the Bronze Age ancestors of the Greeks of the 8th and 7th centuries B.C. ; these myths and legends were handed on by bards who wandered among the towns and no doubt altered their stories and songs to flatter the particular prince whose wine they were drinking.

The epics of Homer are crystallisations of some of the great legends ; Hesiod, the first surviving Greek writer who set out to give advice and information, shows how the Greeks, who could never unite politically, managed to draw their gods into one family and their myths into one system.

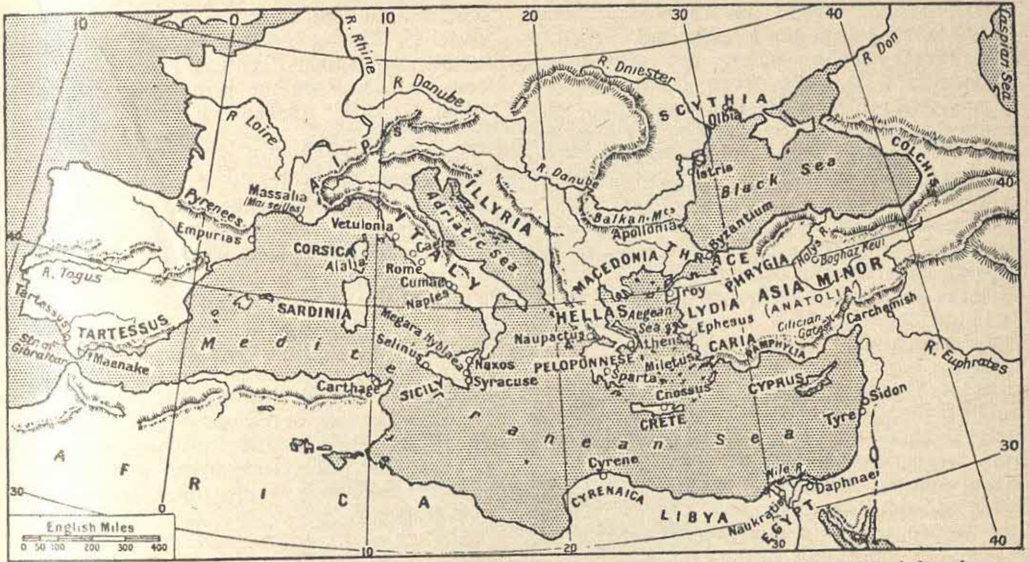
LESSON 7

Greek Colonisation

FROM the mists of the Heroic Age the Hellenic tribes emerge into the daylight of history. The Hellenes were not a nation ; they did not even form a confederation, except when some group combined for a common military purpose. But collectively they occupied the whole of what is now called Greece, the Aegean Isles, and the north and east coastlands of the Aegean Sea. From west to east the Dorians dominated the south. The earlier Archaean element held its own in Attica and Ionia ; the Aeolic element remained in Aeolis, in Boeotia, and Thessaly ; the kindred but more backward tribes of Macedon and the western mountains were not acknowledged as Hellenes, though their ruling families claimed descent from the Heroes. The whole area thus described is what was meant by Hellas.

In the Heroic Age the great racial groups were divided into normally independent communities, each having its own god-descended king who ruled it patriarchally, assisted by high-born councillors. This system was perpetuated by geographical conditions ; each small territory was separated from its neighbours by difficult but not impassable hills, which discouraged communication without preventing it. Thus arose the many small city states of ancient Greece, each jealous for its independence, though many became dependent on, or subject to, a more powerful neighbour. The inhabitants of those states which had good harbourage took readily to seafaring.

The Gulf of Corinth partly isolated the Peloponnese from the rest of the mainland of Greece proper, making it a geographical unit ; after long rivalry between its Dorian states Sparta achieved a primacy or hegemony (to use the recognized Greek term) in the whole Peloponnese, and actual sovereignty over the greater part. Most of the islands were usually political units, though rival cities contested rule



GREEK COLONISATION. In the 8th century B.C. pressure of population in the Greek cities led to the founding of Greek colonies on the coasts of the Mediterranean. The chief settlements are indicated in this map. Sometimes, as in Sicily, colonies of Phoenicians were expelled and their settlements seized. Syracuse, Massalia, Ephesus, and eventually Byzantium, grew to be as great as or greater than their parent cities.

within the larger of them. North of the Peloponnese, Athens and Corinth were at first only larger units among others equally free. In Ionia the city states, in touch with eastern countries, for long outstripped the rest in culture and material prosperity. It was there, not in European Hellas, that Homer sang.

Expansion of City States

Sharing their gods, their legends, and their language—which was recognizably the same, despite variations of dialect—the Greeks tended to despise as barbarians all those who were not Greeks, for when they began to colonise elsewhere in the Mediterranean they naturally avoided coasts where the older Egyptian and Phoenician civilizations were already established. Cities which began to feel a need for expansion, or a pressure of overpopulation, sent their ships chiefly north or west to found what are called colonies, although in fact each new city so founded became an independent state, recognizing no more than a sentimental bond with the mother city. Greek colonies were set up as far west as Massalia, the modern Marseilles, and as far south as Cyrene on the African coast, between the Nile delta and the Phoenician colony of Carthage. Most of this western expansion took place between 700 and 600 B.C. In most Greek cities patriarchal monarchy disappeared, giving place to the rule of oligarchies, small groups of the noble families from which royal councils had been formed.

Aristocracies and Tyrannies

Such aristocracies were apt to be efficient but oppressive to the great body of freemen; some freemen became wealthy and powerful, showing no more consideration than the aristocrats for the class from which they sprang.

Hence arose rival factions of the ruling class, who disputed control between themselves as well as with the *demos* or common people.

Sometimes the oligarchies held their own; here and there level-headed leaders among the

CITY OF THE VIOLET CROWN. This view of the Acropolis, seen from modern Athens, shows the ruins of the Parthenon and other magnificent buildings of the 5th century B.C.

nobles carried reforms and evolved a democratic state; commonly a leader who posed as a democrat effected a military revolution which made him a despot. Such despots, called tyrants, were often able and sometimes very progressive rulers; frequently they reigned with the cruelty which later gave the word tyranny its sinister meaning. After a generation or two a tyranny was often overturned by a counter-revolution, which either established democracy or restored the oligarchy. Conflict between oligarchs and democrats led to intrigue with the corresponding parties in other states, and inter-state conflicts were complicated by factions at home.

By the beginning of the 6th century B.C. the cities of Magna Graecia (" Greater Greece "), notably Syracuse in Sicily and Tarentum in Italy, rivalled those of Hellas proper in power and prosperity. In Hellas some states had already passed through an era of tyranny and emerged from it as oligarchies. Sparta was on her way to the dominant position which she attained by the middle of the century.

In Sparta was developed a unique and rigid political system which involved government by two kings and dedication of the state to military efficiency. As a result, Sparta became the natural war leader of Hellas. She was able to form and dominate the Peloponnesian League, which no other Hellenic power could afford to challenge.

Government of Athens

Outside the Peloponnese, Attica was united with Athens in a common citizenship. In the 7th century B.C. Athens was controlled by the most progressive of the aristocracies; in the first half of the 6th century B.C. she was converted into a democracy by the legislation of Solon; and though she then passed beneath a tyranny, her tyrant was Pisistratus, a dictator who ruled through constitutional forms. The city had not yet developed the sea power on which her future political greatness was built, and she was not yet regarded as the rival of Sparta. Boeotia lay under the sluggish domination of Thebes.

The cities of Ionia were mostly ruled by tyrants who recognized as overlords first the Asiatic kings of Lydia, later the satraps (civil governors) of the newly-born Persian Empire.

LESSON 8

Rise of the Persian Empire

The Assyrian capital, Nineveh, was destroyed in 612 B.C. by Nabopolassar of Babylon and Cyaxares the Mede. For a century the Median power had been rising, pressing upon northern Mesopotamia and across the lands once ruled by the Hittites, attacking the Phrygian kingdom which the Assyrians called Mushki, whose kings in Greek legend bear the name of Midas. The Medes and the Persians behind them were " Aryans "; the fall of Elam removed the barrier that had held them back in the regions to south of the Caspian Sea. The Phrygian power was finally shattered in a struggle with a horde of outer barbarians known as Cimmerians, who swept into Asia Minor across the Bosporus but were finally expelled by the rising western kingdom of Lydia. Thus before Nineveh fell the Phrygian power was broken; Lydia and Media were contesting the overlordship of Anatolia (i.e. the bulk of Asia Minor) while the new Babylonian empire was establishing itself in Mesopotamia. To the east of the Medes their Persian kinsmen were occupying the mountains of Elam under a semi-independent dynasty, the Achaemenids.

CYRUS THE GREAT (c. 600–529 B.C.). Bas-relief representing the deified Persian monarch.

In 585 B.C. (after a solar eclipse by which the date has been fixed) the Lydians and Medes agreed to make the river Halys, which flows into the Black Sea, the boundary between their dominions. The king of Lydia was the fabulously wealthy Croesus, to whom the tyrants of the Greek cities submitted themselves one by one; they were incapable of combining to offer resistance, and Croesus confirmed them in their own tyrannies. Then, about 559 B.C., came the Persian revolution in Media.

Cyrus the Great

The young Achaemenid king of the Persians, Cyrus, heir through his mother of the Median king Astyages (the Greek forms of such names are now the most useful), united the kingdoms of the Medes and Persians without difficulty. Much legend has gathered around the name of Cyrus the Great, who won and ruled a greater dominion than any conqueror before him.

He was admired by his contemporaries as a warrior and a bringer of peace. His victories were free from the barbarities of preceding conquests. Deported populations were restored to their former homes; there was no interference with religion or local customs. Croesus of Lydia was connected with the old royal family of Media; Cyrus quickly accepted his challenge, conquered Lydia and added the country to the new Persian empire, no change being made in the status of the Greek cities.

CROESUS (595-546 B.C.). King of Lydia, so wealthy that his name has become legendary. Croesus was captured by Cyrus and condemned to death by burning, but he was spared at the last moment. This picture is from an Attic amphora of c. 500 B.C.

Cyrus had never heard of Sparta, and was amused by a message from oversea that he must not interfere with the Hellenes as the Spartans would not permit it. He then turned to Babylonia, which since the death of Nebuchadnezzar had been ruled by the learned and placid Nabonidus, who had made his son Belshazzar viceroy in Babylon itself. Tradition tells that Cyrus captured the city by diverting the waters of the Euphrates, which flowed through it, and using its dry channel as a roadway. That was in 539 B.C.; the Mesopotamians offered little resistance, and Babylonia and Syria were soon overrun. Ten years later Cyrus died, or was killed, while campaigning against Scythian hordes beyond the river Araxes.

Cambyses, the son of Cyrus, easily conquered Egypt. His plan to seize Carthage was frustrated by the refusal of Phoenician sailors to sail against their remote kinsmen. Cambyses died on his way back to Persia to deal with a Median pretender.

The Empire of Darius

Darius Hystaspis (son of Hystaspes), a cousin of Cyrus, surprised and slew the pretender and assumed the crown of the Medes and Persians. The Persian party supported him; he crushed opposing factions and set about the organization of his empire, extending beyond that of Cyrus and of all previous empires put together.

Cyrus was primarily a conqueror, but he established new principles on which the new empire was to rest: clemency to the vanquished, religious toleration, and the protection of established custom. This great dominion was divided into between twenty and thirty provinces or satrapies, each having its own satrap or civil governor, holding office at the king's pleasure. Besides the satrap, and responsible not to him but to the king, was the commander of the provincial forces. A third royal official, an agent or secretary, was in constant communication with the central government at Susa or Persepolis. The king kept the central Persian province in his own hands, and the balance of power in each province made it hard for any local official to rebel.

Local administrations were as far as practicable retained; local princes and chiefs whose loyalty might be relied on became officers under the government; local gods, deported by Assyrians or Babylonians, were restored to their shrines, though the fire-worshipping Persians had little respect for idolaters. Above an ancient road from northern Persia to Babylon, Darius carved on the rock of Behistun (now called Bisitun) a record of victory in Babylonian, Elamite, and Old Persian scripts, leaving for posterity a key to the two older languages.

PERSIA'S GREAT KING. On this rock sculpture at Behistun, Darius thanks the god Ahura-mazda (Ormuzd)—represented within a winged disc—for his victory over nine satraps who appear before him as prisoners roped together.

LESSON 9

Greece and Persia in Collision

IN the first quarter of the 5th century B.C. the Persian empire seemed destined to indefinite and almost automatic expansion. When, about 517 B.C., Darius had secured his own position as Great King (the title bestowed by the Greeks), he made no serious effort to add to his dominions. His eastern expeditions penetrated to the borders of India and exacted the same sort of nominal submission as did Caesar's visits to Britain nearly five centuries later ; but their purpose was to secure the frontier against the incursions of Scythian marauders, the term Scythian including all the more or less nomadic tribes of central Asia and of south-eastern Europe between the Caspian Sea and the Danube. In 514 B.C. Darius led or sent an expedition to Thrace, which failed to bring the Scythians to battle and had to retire from empty country in which the troops could not be fed.

The Peloponnesian League

The Peloponnesian League was operated by an arrangement of alliances between Sparta and individual states which pledged themselves to accept Spartan leadership in war and to support the Lacedaemonians and their allies. It was joined by all the Peloponnesian states except Argos, a defeated rival of Sparta.

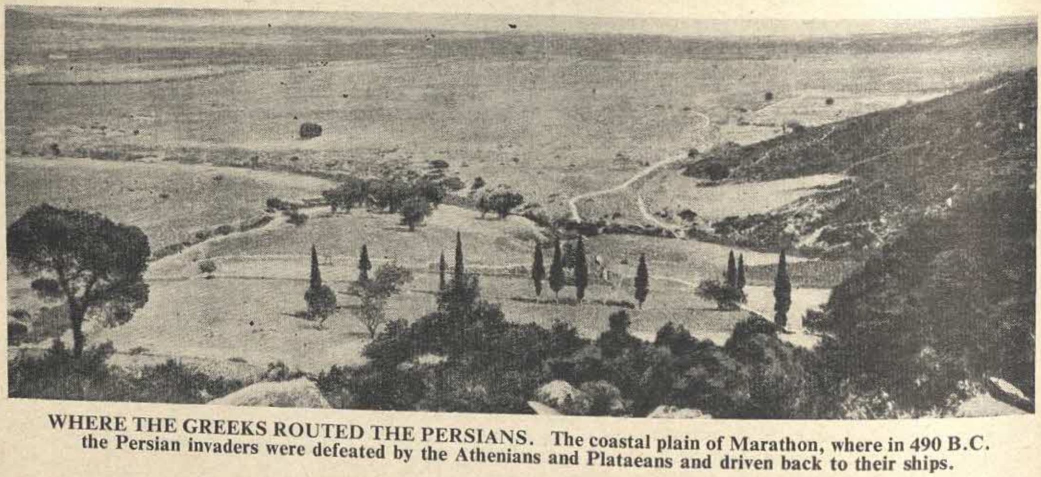
Spartan military ascendancy had resulted from special development of heavy infantry, armed with the spear and the great shield, and known as *hoplites*, who fought in massed ranks ; but Sparta had no fleet. Athens, though conspicuous among the other states, had no such prestige as Sparta ; in 510 B.C. her tyrant, Hippias the son of Pisistratus, was expelled. On the basis of Solon's constitution the Athenians then developed the most democratic form of government known to the ancient world.

The Ionian cities had always resented subjection to the mild barbarian rule which their tyrants found convenient, but no practical resistance was offered, and no change of system followed, when Persian authority displaced the Lydian. In 500 B.C., however, a disappointed member of the tyrant family in the city of Miletus, posing as a democratic leader, succeeded in stirring up a general revolt against tyrannies and against the satrap of Lydia, their supporter ; and he appealed to western Hellas to join in the liberation of the Asiatic Hellenes.

There was little response, but in 499 B.C. Athens and her neighbour Eretria, in the island of Euboea, sent contingents to aid the rebels, who attacked Sardis, the capital of Lydia, and by accident set the city on fire. The revolt failed, as it was bound to do ; the western contingents reached their ships and went home. The burning of Sardis angered Darius ; remote and insignificant states must not be allowed to interfere with a Persian province. He sent to the Greek cities to demand " earth and water," symbolising submission to the Great King. The demand was rejected, and in 490 B.C. he dispatched a punitive expedition (not a great army), to deal first with the chief offenders, Athens and Eretria.

Battle of Marathon

The expedition was ignominiously defeated by the Athenians on the seaside plain of Marathon. Darius was occupied by what seemed more serious trouble in Egypt, and it was



WHERE THE GREEKS ROUTED THE PERSIANS. The coastal plain of Marathon, where in 490 B.C. the Persian invaders were defeated by the Athenians and Plataeans and driven back to their ships.

not till some ten years later that his son Xerxes set about a proposed conquest of Hellas.

The name of Marathon rings down the centuries, a trumpet-call to lovers of liberty. It was, in fact, a startling achievement, which enormously increased the prestige of Athens; assisted only by a small contingent from Plataea, the Athenian hoplites proved the superiority of their training and armament to those of an immensely larger force of the best Oriental troops. The victory was, however, no more than a check; it was obvious that the Persians would return in increased strength. Athens awoke to the fact that the sea was her element; in the next ten years she created a powerful fleet.

GREEK "HOPLITE." This bronze statuette from Dodona shows the type of equipment that helped to win the victory of Marathon.

Thermopylae and Salamis

In 481 B.C. Xerxes gathered from all parts of his empire an immense army, exaggerated by the historian Herodotus to 1,700,000 men. It crossed the Hellespont in 480 by a bridge of boats, and marched through Thessaly, whose inhabitants had no choice but to submit, since the southern states could send no force to face so vast a host in the open. A Greek army waited in the pass of Thermopylae, but retreated when it found the pass had been turned and must become a death-trap. Only the three hundred Spartans, under their king Leonidas, chose to die fighting—a useless military gesture which won them immortal fame.

The Peloponnese was accounted safe behind the Isthmus, except from attack by sea, but Athens was untenable; its whole population withdrew to the neighbouring islands of Aegina and Salamis, where the fleet secured them from attack, while the barbarians ravaged Attica and destroyed the city. Yet the safety of the Peloponnese also depended on that fleet, since the Persian fleet was also at hand. The diplomacy of the Athenian Themistocles prevented the withdrawal of the other contingents and inveigled the Persian fleet into the bay of "seaborn Salamis"; to Athens and to Themistocles belongs the glory of the tremendous sea-fight which for the time saved Greece.

This great victory was not in itself decisive. Xerxes carried a large part of his undefeated army home, but he left behind him a force three or four times the size of any possible Greek muster. The decisive campaign was fought next year (479 B.C.), when the Persian host was shattered at Plataea.

The main part in this battle was borne by the Spartans; Athenians and others were there, but Athens was still playing her part chiefly on the sea, and on the same day, if a doubtful tradition be accepted, won at Mycale on the Ionian coast a victory which ensured the liberation of Ionia. In the same year, if not also on the same day as Salamis, the Hellenes of Magna Graecia (i.e. southern Italy and Sicily), headed by Syracuse, won a decisive victory over another Oriental power, the Carthaginians, whose aggression had prevented them from taking part in the struggle against Persia. So ended the first invasion of Europe from Asia. Not until many centuries had passed was the attempt made again.

LESSON 10

Pericles and the Peloponnesian War

NEARLY a century and a half after the Asiatic invasion of Europe, an organized army of Europeans invaded Asia. In the first half of that period were the great days of Athens, the first imperial democracy in history. Those days contained the climax of her magnificence in art and drama, while Plato learned from his master Socrates the essentials of the philosophy of which he himself became the supreme exponent.

After the defeat of the Persians, Athens retained the leadership at sea which Sparta had never lost on land. Greek maritime supremacy was necessary for the full liberation of Ionia; at Salamis, in the fleet of Xerxes, the Ionian crews had turned their vessels against the Persians, showing their solidity with the Greeks of Hellas. The Peloponnesian League remained indifferent to sea power; Ionia and the islands looked to Athens.

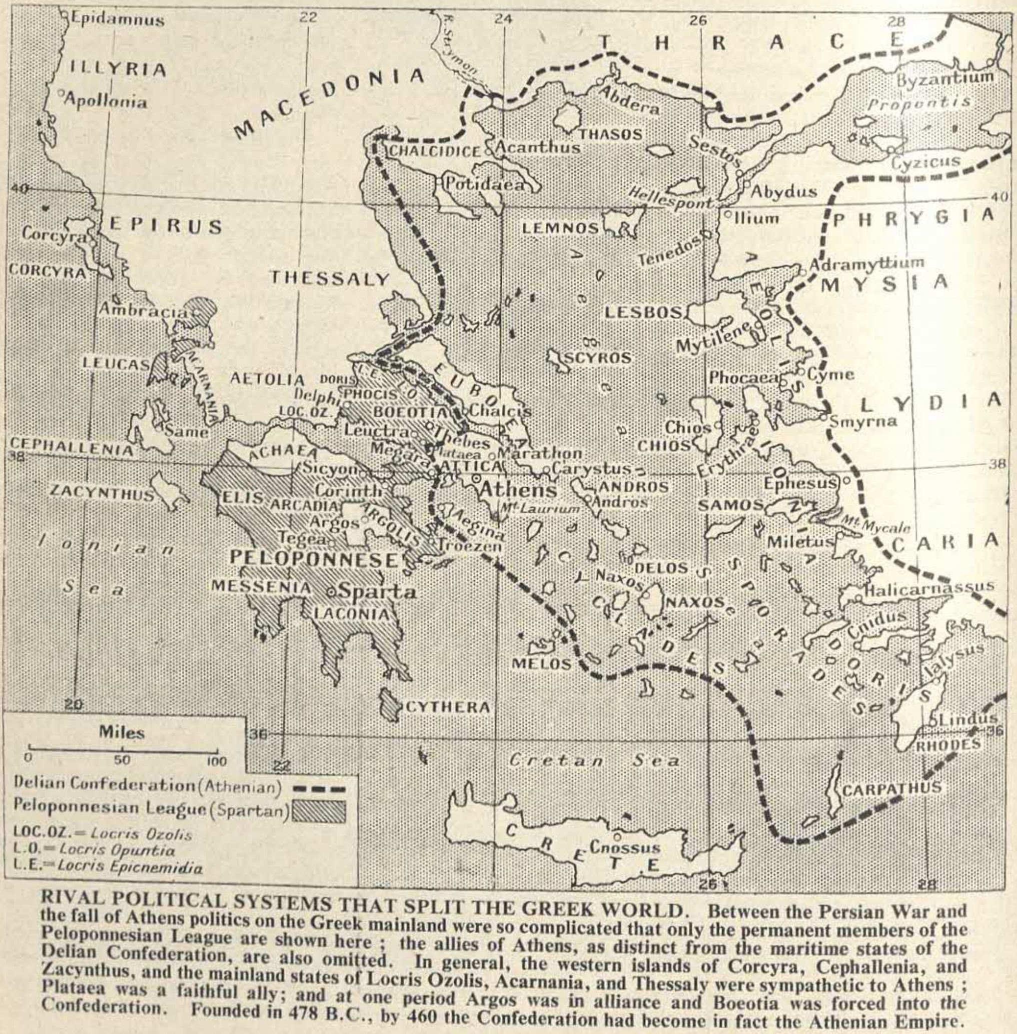
The result was the formation by Athens of the Delian Confederation, a league of maritime cities whose members contributed each their quota to the Delian fleet, the command of which was by treaty conveyed to Athens ; the island of Delos, which contained a famous shrine of Apollo, was chosen as official headquarters. Members might, and for the most part did, contribute ship-money instead of ships, the ships in such cases being provided by Athens and forming part of her own fleet. The Delian Confederation was, in effect, the maritime counterpart of the Peloponnesian League, with Athens at its head.

Rivalry between Athens and Sparta

In course of time it became the instrument of empire rather than of hegemony, for two special reasons : in the council of the Confederation all member cities had an equal vote, but so many of them were practically client states of Athens that she could always command a majority ; and an understanding developed that, though the association had nominally been voluntary, no state having once joined was free to withdraw. Jealousy and opposition between the Peloponnesian League and the Delian Confederation were inevitable as soon as the Persian menace faded. A few military clashes between Athens and Sparta or allies of Sparta had already taken place when in 454 B.C. the Delian treasure was transferred to Athens. Thenceforward the Delian fleet was in effect the Athenian navy.

Athens under Pericles

The aggrandisement of Athens became the primary object of the great statesman Pericles, who wielded almost continuous power from about 460 till his death in 429 B.C. For him



RIVAL POLITICAL SYSTEMS THAT SPLIT THE GREEK WORLD. Between the Persian War and the fall of Athens politics on the Greek mainland were so complicated that only the permanent members of the Peloponnesian League are shown here ; the allies of Athens, as distinct from the maritime states of the Delian Confederation, are also omitted. In general, the western islands of Corcyra, Cephallenia, and Zacynthus, and the mainland states of Locris Ozolis, Acarnania, and Thessaly were sympathetic to Athens ; Plataea was a faithful ally; and at one period Argos was in alliance and Boeotia was forced into the Confederation. Founded in 478 B.C., by 460 the Confederation had become in fact the Athenian Empire.

Athens was meant to rule as the incarnation of all that was best in Hellas.

PERICLES (c. 499–429 B.C.), Athenian statesman. His ideal was to create a great Greek Confederacy led by Athens.

Pericles had won his position at Athens as a democratic opponent of the aristocratic party, which was friendly to Sparta ; he introduced many popular domestic reforms, bought land from allied cities for settlements of Athenians, and arranged that restoration of Athenian temples which showed the full flowering of Hellenic art and architecture. At the same time he worked continuously to increase the power and scope of Athens within the Delian Confederation.

30 Years Peace

This policy stirred many of the subordinate states to revolt, and gave opportunity for hostile action by the Peloponnesian League. Formal peace with Persia was not concluded until 447 B.C. ; in 445 Pericles was forced to accept a 30 years peace with the league by which Athens lost most of her recent territorial gains, but he retained his influence in Athens, and Athens retained her maritime power. In 432 B.C. Sparta demanded the " liberation of the Greeks " held in subjection by Athens. Pericles replied that Athens was willing, provided that Sparta would set the example ; and in 431 B.C. the Peloponnesian War began.

Thucydides' Account of the War

The story of the war is magnificently told in the pages of the Athenian historian Thucydides. The war brought about the downfall of Athens and the disappearance of the Periclean ideal, perhaps because Athens lost that ideal after the death of Pericles in the third year of the war. For ten years Athens held her own ; in 422 B.C. both principals were ready to patch up a peace.

Corinth Prolongs the Struggle

There was a great exchange of prisoners and occupied places, but various allies of Sparta—especially Corinth, the keenest commercial rival of Athens—were unwilling parties to the proposed settlement. The Peloponnesian League fell apart, but when war was renewed in 418 B.C. the Spartans won the battle of Mantinea. In 415 B.C. the Athenians, under the influence of the brilliant and reckless aristocrat Alcibiades, made an unprovoked attack on the hitherto independent island of Melos and killed or enslaved the inhabitants. In 415 B.C. Athens embarked on her fatal Sicilian adventure ; its pretext was an appeal from some Sicilian cities for aid against Syracuse. The expedition put an enormous strain on the Athenian resources ; its conduct was a series of blunders. The command was given to an estimable but incompetent general, Nicias, and Alcibiades deserted to the Spartans. Disaster followed disaster ; the entire expeditionary force was slaughtered or taken captive and sold into slavery. The Ionian cities rebelled, and the Spartans put a navy to sea ; yet the Athenians fought on with persistence, accepted an oligarchy and turned it out of power again, destroyed a Spartan fleet at Cyzicus (410 B.C.), recalled Alcibiades, and campaigned with some success against the Persians who became allies of Sparta.

Fall of Athens

Finally, they lost their own fleet by a piece of almost incredible ineptitude : at Aegospotami the crews were allowed to go ashore and leave the ships unguarded ; they were surprised, and almost all the vessels were captured by the Spartan commander Lysander (405 B.C.). Without a fleet Athens was helpless, and only a temporary lapse into magnanimity on the part of Sparta saved her from annihilation (404 B.C.).

TREATY IN STONE. After the disaster of Aegospotami in 405 B.C. the only friend of Athens was Samos. A treaty between them, carved on this marble block, is symbolised by the figures of Athena and Hera, patron goddesses of the two states.

LESSON 11

Beginning of the Hellenistic Age

SEVENTY years elapsed between the fall of Athens and the invasion of Asia by Alexander the Great (356–323 B.C.). In those years the Hellenic states gave final proof of their inability to unite, while the Persian Empire suffered the drawbacks usual among Oriental despotisms, where the succession is often in dispute, and personal weakness in the monarch excites the ambition of provincial governors. Towards the close of the period Philip II, father of Alexander the Great, made of his semi-Hellenic kingdom of Macedon a strong military power, assumed hegemony over Hellas, and planned the creation of a Hellenic empire in Asia.

The Anabasis

The Greek states had ceased to regard Persia as a menace. The end of the Peloponnesian War (431–404 B.C.) left numbers of disbanded Greek soldiers ready to sell their services wherever fighting and loot might be expected. A Persian prince, Cyrus the younger, resolved to revolt against his brother, King Artaxerxes, and collected ten thousand Greeks to strengthen the army of Asiatics which he commanded as a satrap in Asia Minor. With this force he marched (401 B.C.) eastwards into Mesopotamia, and met Artaxerxes at the battle of Cunaxa. When his victory seemed almost assured Cyrus was slain; his Asiatic troops fled, but the Persians did not venture to continue the fight against the ten thousand disciplined and unbeaten Greeks, for whom there was nothing left to do but to march home through hostile country.

PHILIP OF MACEDON. Philip seized the crown of Macedon in 359 B.C. and devoted his genius to creating a Macedonian army which should establish his supremacy in Greece and shatter the Persian power.

The route by which they had come being closed to them, they struck north-west through the mountains, and after almost incredible hardships reached the Black Sea. There they were able to take ship and return to Europe. This famous "Retreat of the Ten Thousand" was led by Xenophon (*c.* 430–*c.* 354 B.C.), who described it in his *Anabasis*. The march was only an "avoiding action," but it taught the Greeks that a Greek force could penetrate Persia and defy the armies of the Great King.

The Spartans, who had freed Hellas from the Athenian yoke, proceeded to impose their own, which Hellas found more galling. Athens soon recovered something of her strength and influence, and joined a confederation headed by her own old enemies Corinth and Thebes. The Spartans asked the king of Persia to arbitrate, and procured in 386 B.C. a pacification known as the King's Peace or the Peace of Antalcidas (the Spartan envoy), by the terms of which Ionia was handed back to Persia. Thebes expelled her Spartan garrison; and the great Theban soldier and statesman, Epaminondas (*c.* 418–362), won a brilliant victory over the Spartans at Leuctra (371 B.C.).

When Epaminondas fell at the battle of Mantinea, nine years later, the hegemony of Thebes went the way of its predecessors. The future of the Hellenes appeared to lie rather in Magna Graecia than in Hellas proper; for there a Syracusan tyrant, Dionysius (430–367 B.C.), drove the Carthaginians (who had renewed their aggression) into a corner of Sicily, and brought under his own rule the Sicilian Greeks and the Greek cities on the coasts of the "boot" of Italy. Dionysius acted with a combination of military genius, generosity, and ruthlessness which has few parallels, and was also renowned for patronage of art and literature. But his dominion, too, was dependent on his own personality, and went to pieces after his death in 367 B.C.

The next champion of Hellenism was Philip of Macedon (382–336 B.C.) who had passed some years of his youth as a hostage in Thebes, when Epaminondas was at the height of his renown.

Philip of Macedon

From the great Theban, Philip learned the art and science of war; he also acquired an admiration for Athens which never forsook him. At the age of 20 he was allowed to return to Macedon, where his brother Perdiccas II was king. Three years later Perdiccas was killed in battle; Philip assumed the regency (359 B.C.) on behalf of the child-heir Amyntas. He at once set about the organization of the kingdom, the subjugation of the neighbouring tribes, and the improvement of the army; presently he usurped his nephew's crown.

Sparta, Athens, and Thebes had failed to unite the Greek states for any common purpose. Macedon must fail, too, unless she proved that she was irresistible. Philip had no desire to interfere with the internal affairs of the Greek states ; he intended to establish supremacy by conquering not Greeks but Thracians and Illyrians. The arguments of the brilliant Athenian orator and statesman, Demosthenes (*c.* 382–322 B.C.), have too adversely affected historical judgements of Philip's actions. Demosthenes stood for individual independence, in all circumstances, of every Hellenic state. Philip sought co-operation, and above all the co-operation of Athens, though compulsion might be the necessary alternative. Demosthenes could see, and persuaded the Athenians to see, in Philip nothing but the self-seeking tyrant.

Philip attained his object by intricate diplomacy and by fighting during the first twenty years of his rule. Several times he came into collision with Greek states, but he refrained from crushing them. He won admission to the Amphictyonic Council, which was supposed to regulate the religious affairs of Hellas, became its president, and so gained Hellenic status, in 346 B.C. He completed the incorporation of Thrace with Macedon five years later. In 338 B.C. a quarrel in which the Amphictyonic Council was concerned forced upon him a war with Thebes ; Athens joined Thebes, and Philip defeated their united forces at Chaeronea. Thebes paid a heavy penalty ; Athens was treated generously.

Having shown that Macedon was irresistible, Philip summoned a congress of the states of Hellas (337 B.C.), from which Sparta alone stood aloof. To this congress he unfolded his tremendous scheme. Hellas, with himself in supreme command of her armies and fleets, was to attack the Persian Empire and shatter it for ever. The congress assented without enthusiasm. Philip departed to the north to organize the opening campaign ; but in 336 B.C., the 23rd year of his rule, he was assassinated at his daughter's wedding.

LESSON 12

Alexander the Great and his Empire

On Philip's death his son Alexander (356–323 B.C.) came to the throne of Macedonia and its conquered or dependent states. Alexander was then in his 21st year. In boyhood and youth he had been the pupil of the philosopher Aristotle, with the result that he was devoted to traditional Hellenic ideals. Philip set him at a very early age to learn by experience the arts of government and war. At 16 he was acting as regent in his father's absence. Two years later he commanded his father's cavalry at the battle of Chaeronea.

ALEXANDER THE GREAT (356–323 B.C.), king of Macedon and Hellenic emperor.

When he came to the throne he at once found himself compelled to continue his father's war-like policy. Campaigning by the Danube, he received news that the Macedonian garrison in Thebes had been massacred. He returned with speed, recaptured Thebes, slaughtered many of its defenders, sold many more into slavery, and burned the city, sparing only the descendants and house of the long-dead poet Pindar. The other Greek states conferred on Alexander the office, previously bestowed upon Philip, of commander-in-chief for the conduct of the war with Persia.

Alexander crossed the Hellespont (Dardanelles) in 334 B.C. with 30,000 foot and 5,000 horse, and won a brilliant victory over the Persians near the river Granicus that flows into the Propontis, now the Sea of Marmora. The Persian army is stated to have numbered more than 100,000 men. The Persian ruler was Darius III (reigned 336–330 B.C.), of the same family as Darius I. Alexander marched southward along the coast of Asia Minor with the intention of capturing all the strong places on the shore of the eastern Mediterranean, to prevent Darius from attacking Greece.

Darius made more than one attempt to check the Greek advance, but Alexander routed him near Issus, on the south-east extremity of Asia Minor, and laid siege to the city of Tyre, which he captured after a protracted struggle. This ensured him the command of the sea. He made himself master of Egypt, where he assumed the character of son of the god Amen and founded the city of Alexandria to be a meeting place of the trade of East and West. The West secured, he advanced through Palestine and Assyria, traversed the Euphrates, where the Persians made no stand, and the Tigris, which they unsuccessfully attempted to defend ; and on the famous battlefield of Gaugamela or Arbela he won his third and decisive victory over Darius.

The Persian king fled before the conqueror, who swept on to Babylon, Susa, and Persepolis, where enormous treasure fell into his hands ;

ALEXANDER IN BATTLE. Reliefs decorating the sarcophagus of a Sidonian ruler, found at Sidon but now at Istanbul, were executed shortly after Alexander's death in 323 B.C. This photograph of a portion of the carvings shows Alexander pursuing a Persian horseman.

then he pursued Darius, and found him murdered by one of his satraps (330 B.C.). Alexander returned to Babylon, where he restored the temple destroyed by Xerxes, and occupied in succession all the other Persian cities.

Attempt of India

Alexander was now sovereign of Persia, which he made a part of the Macedonian empire. A new ruthlessness appeared in his treatment of captives and suspected conspirators. Not yet satisfied with his conquests, he planned to add India to them. An opportunity occurred when the king of one of the states in the Punjab asked for aid against a rival, Porus, whom Alexander completely defeated. He dealt generously with his captive, partly no doubt to secure his genuine submission and alliance; Porus was allowed to retain his kingdom on condition of keeping all that part of the country in obedience to Alexander.

The war-worn Macedonian troops refused to advance beyond the Punjab. Alexander subjugated the whole Indus valley, built a fleet which explored the coasts for purposes of trade, and marched back to Babylon. In the deserts of Baluchistan his army suffered greatly from lack of food and water. Hardly more than a quarter of the army with which he had set out returned with him to Persia, but he had shown Europeans the road to India.

Alexander was a great statesman as well as a great soldier. He diffused the culture, civilization, and language of Greece wherever his conquests spread. To him the ancient world owed a vast increase in knowledge, and he was one of those conquerors who founded imperial systems without leaving a dreadful trail of destruction. He understood that no military force from Greece could maintain his rule in Asia. His policy was to treat vanquished or surrendered countries with such equity and generosity that their inhabitants would become free and prosperous citizens of his empire. He encouraged Macedonians to marry Asiatic women, and he promoted commerce between Greece and the East. His taking upon himself the status of the son of a god was part of his action as a liberator and uniter. He was possibly the first great ruler to be loved as well as feared. Alexander was only 32, and had reigned for only 12 years, when he was stricken by disease at Babylon. In a fortnight he was dead.

LESSON 13

The Heirs of Alexander's Empire

ALEXANDER'S sudden death at the height of his power and fame (323 B.C.) prevented him from carrying out the Hellenisation of his empire. He had exalted the Greek way of life as a pattern for the rest of his world, but the Greek cities themselves had had small share in his feats of arms. He had won his battles with Macedonian troops led almost entirely by Macedonian generals; these generals were able commanders who knew Alexander's plans, but only one of them had the vision to attempt fulfilment of those plans. Alexander's heir was either a feeble-minded half-brother, Arrhidaeus, called Philip III, or a posthumous child, the son of Alexander's wife, Roxana. The generals acknowledged Philip and appointed Perdiccas his guardian; five of them divided the empire and began to rule as viceroys.

Antipater, whom Alexander had left as regent in Europe, retained his position; Egypt was allotted to Ptolemy; Babylonia and the farther East to Seleucus; part of Asia Minor to Lysimachus, and the remainder to Antigonus. The ambition of Perdiccas caused his overthrow by the viceroys in 321 B.C. Antipater died two years later, and was succeeded after a brief interval by his son, Cassander. Philip III and the infant son of Alexander were done away with. Nearly forty years of struggle, involving exhausting wars by land and sea, resulted in the emergence of three great independent kingdoms —Egypt, Syria, and Macedonia. Their rulers are known collectively as the Diadochi, or Successors.

In Egypt, Ptolemy (367–283 B.C.) became the founder of a great family of rulers comparable with any dynasty of the Pharaohs. He built a fleet, which gave him command of the Mediterranean and the Red Sea, and carried his power into the Indian Ocean. He made his capital at Alexandria, founded by Alexander in the Nile delta ; for a while his armies possessed Syria and Palestine. Ptolemy made no attempt to Hellenise his realm, but ruled as an Oriental despot, taking advantage of the Egyptian system of taxation to maintain vast armies and fleets. He and his earlier successors patronised literature and the arts ; their foundation of the Alexandrian museum and library attracted the greatest scientists and writers of the age. The Ptolemaic dynasty degenerated, and came to an end in 30 B.C. with the suicide of Cleopatra (whose boy-husbands had been Ptolemys XII and XIII) and with the Roman conquest of Egypt.

Seleucus alone of the Diadochi pursued Alexander's ideals with persistence. He and his son Antiochus I (*c.* 280–261 B.C.) planted Hellenic colonies far to the East and gave them self-government along Greek lines. In India the great Maurya kingdom had been established soon after Alexander's invasion. The Punjab was included in the Maurya dominions, and the Macedonian garrisons left there were forced to retire. Seleucus gave up the idea of reconquest, and made a treaty of friendship with the Maurya king, Chandragupta. Even without its temporary foothold in India, however, the Seleucid empire spread Greek culture far into Asia. The immediate successors of Antiochus I lost much of this power ; war with Egypt cut Syria away, and states in Asia Minor recovered independence, so that Antiochus III succeeded to a diminished inheritance. He set about recovering its greatness, but his challenge to Rome broke up the power of the Seleucids.

Under Macedonian overlordship the Greek cities were nominally free when Alexander invaded the East. Attempts at revolt were frustrated by Antipater ; then the cities became pawns in the struggle between the sons of Antipater and Antigonus. Early in the 3rd century B.C. the foremost figure in the European Hellenic world was Pyrrhus (318–272 B.C.), king of Epirus, the country situated between Macedonia and the Adriatic Sea ; his father was the brother of Olympias, the mother of Alexander the Great. Pyrrhus is best known for his exploits in Italy and Sicily (mentioned later) ; he also fought Antigonus Gonatas—grandson of the great Antigonus—then king of Macedonia, and for a brief while Pyrrhus obtained possession of that country. His reputation as a soldier was second only to that of Alexander himself, but his love of fighting was insatiable ; in his next campaign he was killed by a tile thrown by a woman from a roof-top in Argos (272 B.C.). Antigonus Gonatas won back the throne of Macedonia and held it until his death in 239 B.C.

The Last Hellenic Leagues

Some of the Greek cities had supported Pyrrhus, and Antigonus took his revenge by establishing in them tyrants under his own control. Greek independence reappeared for a while with the formation of the Achaean and Aetolian Leagues among states on the northern and southern shores, respectively, of the Gulf of Corinth. As usually happened with alliances in Greece, the leagues were generally rivals if not actively hostile to each other ; but both withstood the power of Macedonia, and both fought the piratical Illyrians, so coming into friendly relations with Rome which lasted for many years. Before the leagues collided a revival of political activity in Sparta brought her into conflict with the Achaean League, which appealed somewhat rashly to Antigonus Doson, regent of Macedonia, who crushed Sparta (224–221 B.C.). Eventually both leagues found themselves in opposition to the Roman power ; first the Aetolians and later the Achaeans were conquered by the Romans.

The Syracusan empire which Dionysius had built up fell to pieces in the hands of his son after the

CLEOPATRA (69–30 B.C.), queen of Egypt at the age of 17. Loved by Julius Caesar and Mark Antony, she committed suicide on Antony's defeat by Octavian.

middle of the 4th century B.C. Carthage spread her dominion from the west of the island while the Greek cities quarrelled, until the Syracusans appealed to their mother-city, Corinth. Timoleon, the great Corinthian captain, came to the rescue with a force of 700 men and with the Syracusans drove the Carthaginians back. For a time he infused his own public spirit into the Sicilian Greeks; but in 336 Timoleon died, and soon a new tyrant arose in Syracuse—Agathocles, who carried successful war into Africa. After his death the Carthaginian menace brought his son-in-law Pyrrhus to Sicily; Pyrrhus projected the conquest of Carthage, but wasted his strength in a futile contest with Rome. After Pyrrhus left Sicily the tyrant Hiero made himself master of Syracuse, restoring her ascendancy in Sicily partly by maintaining an almost unbroken friendship with the rising power of Rome.

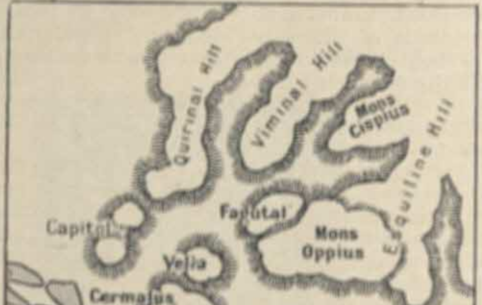
LESSON 14

Beginnings of Roman Power

In the early 8th century B.C., at about the time when the Phoenicians were founding their colony at Carthage on the northern coast of Africa, the story of the next great European civilization began. The traditional date of the founding of Rome is 753 B.C. At that period two races occupied the part of Italy between the Apennines and the western or Tyrrhenian sea. West of the river Tiber were the Etruscans, who were not Indo-Europeans, and may have been akin to the pre-Hellenic people of the Aegean islands. East of the Tiber the Latins, who were of Indo-European stock nearly allied to the Hellenic, had taken possession of the plains and foothills. In the north and east were related tribes called Sabellians, Sabines, or Samnites, probably variants of one name.

Rome arose in a strong strategic position at the lowest practicable crossing of the river whose passage it commanded. According to tradition, Romulus, son of the war god Mars, built the city and there ruled a band of warlike followers. He was succeeded by six other kings, three of whom were Tarquins, foreign kings from southern Etruria. The last, Tarquin the Proud, was expelled in 509 B.C., at the time the Athenians were ejecting their own tyrants.

In fact, the city was probably founded as a frontier fort by Latins, and during its stormy early days was sometimes dominated by Sabines or Etruscans. To begin with, the site contained only villages on the original "seven hills" (shown in the map in darker type), and marshy valleys through which sluggish streams flowed to the Tiber. As the town spread to cover the seven hills of historical times—Palatine, Capitoline, Aventine, Caelian, Esquiline, Quirinal, and Viminal—the streams were embanked between massive walls. The walls of the Cloaca Maxima or great sewer, the beginning of the temple of Jupiter on the Capitoline hill, the Circus Maximus or racecourse, and the city walls themselves, all date traditionally from the time of the seven kings; they may well have been the work of Etruscan engineers, for Etruscan cities had efficient drainage with rock-cut sewers. Rome had two other sewers nearly as large as the Cloaca Maxima, now buried thirty or forty feet below the streets.



EARLY ROME. The original "Seven Hills" are not those which the city subsequently covered but a group within a smaller compass, here distinguished by darker type. They were probably the sites of distinct settlements.

After the expulsion of the kings Rome became a republic ruled by elected magistrates, of whom the two chief were called consuls; at first these officials were all patricians, i.e. of noble descent. At the end of some two hundred years the city was mistress of Italy west of the Apennines; a century later, she was supreme in all the Mediterranean lands west of the Greek peninsula. Another seventy years, and her dominion was spreading into Asia. While this expansion was going on, the forms of republican government changed ; the plebeians or ordinary freemen struggled for a share of power. In the end neither patricians nor plebeians won ; the republic foundered in dictatorships and civil war, and power was shared by the emperors and the armies, with occasional intervention by that offspring of Roman expansionist policy—the pampered and bloodthirsty Roman mob.

The Rival States

At the beginning of the 5th century B.C. it was doubtful whether Etruscans or Latins would come to dominate Italy ; and though the Romans expelled their Etruscan dynasty of Tarquins, they might have failed to sustain their victory but for the fact that the Sicilian Greeks shattered the Etruscan fleet just after the Greek triumph at Salamis (480 B.C.). Thereafter Rome was confronted not with a united Etruria but with great Etruscan cities and Latin rivals, Sabellian highlanders, or Celtic invaders, until she came into collision with oversea powers.

VOTING IN ANCIENT ROME. The ballot was introduced in 139 B.C. for the election of magistrates, and this coin shows an elector dropping his voting tablet into the ballot box.

In Rome the two consuls, the chief magistrates and commanders of the army, could not make laws ; legislation was the function of the assemblies, the *Comitia* ; but only by the magistrates could a new law be submitted. The double magistracy was a security against one man's converting his office into a " tyranny." The magistrates were elected by popular vote, but only patricians were eligible. They could, in an emergency, nominate a " dictator " endowed with sole authority for a term of six months. They were expected to be guided by the council called the Senate ; the Senate itself was a patrician body.

Patricians and Plebeians

The rank and file of the first conquering legions of Rome were the plebeian citizens themselves. Dissatisfied with their political unimportance, and angered by the method of distribution of land they had fought to win for the city, they demanded reforms in vain until they had refused (493 B.C.) to embark on a new campaign. Withdrawing from the city, they took up their position some miles away on a hill afterwards called the Sacred Mountain, and returned only when the patricians agreed to the institution of additional magistracies expressly for protection of the interests of the people. Two plebeian magistrates—the number was afterwards increased—called tribunes of the people, were appointed, having power to introduce and veto legislation and to forbid summary action by the patrician magistrates.

The next important step was the establishment of a written code which could not be perverted or misinterpreted at the will of a magistrate. It is said that the commissioners appointed to study its preparation visited Athens and other Greek cities to collect information. In 452 B.C. another commission of ten men—*decem viri*, the Decemvirs—was appointed to work out the code, and to govern the city for a year (451 B.C.) while it was brought to completion. The code was finally accepted—willingly by the plebeians, unwillingly by the patricians. The laws were written on ten metal tables and set up in the place where the legislative assembly held its sittings.

What followed remains obscure. Two additional tables of law were expected, the Decemvirs were reappointed for a year, and they apparently attempted to transform themselves into a permanent controlling body, headed by an ambitious patrician, Appius Claudius. Legend tells that Appius tried to trap into slavery a free-born maiden, Virginia, whose father saved her from dishonour by stabbing her to death in public. A tremendous riot ensued, the army supported the commons, and the Decemvirs were overthrown.

The tables of the law were a codification of existing custom ; they did nothing to redress

CLOACA MAXIMA. On the left bank of the Tiber, south-west of the Forum, is the exit of the Cloaca Maxima. It still functions as a drain, the lower reaches never falling out of use.

the balance of social justice, and one of them perpetuated refusal to recognize any marriage between a patrician and a plebeian. In spite of senatorial opposition, a law carried in 445 B.C. removed this obstacle.

The next move was the plebeian demand for admission to the consulship. For many years the patricians staved off this advance by a compromise whereby consuls were frequently replaced by military tribunes, for whose office both orders of citizen were eligible. In 367 B.C. a law, named the Licinian after the tribune Licinius who carried it, enacted that one consul should always be a plebeian.

LESSON 15

Rome Fights for Italian Hegemony

From the struggle between the patricians and the free commons, the plebs, or plebeians, arose a new senatorial aristocracy. The Senate, the Council of State, provided the bulk of the magistrates and military commanders, and still practically controlled the government, in spite of having no legislative power of its own ; that power rested in the popular Assembly or Comitia. While their internal conflict proceeded, the two orders continued to make common cause against the external enemies of Rome, gradually and with serious setbacks acquiring hegemony over other Italian states.

Gallic Invasions

In 390 B.C., according to tradition, Gallic (or Celtic) hordes, established in the region between the Alps and the river Po, occupied a strip of the Adriatic coast, dispossessed the Etruscan and Umbrian settlers to the north of the Apennines, and descended to conquer and loot Etruria. They then advanced to Rome, and stormed and sacked the city ; the Capitol withstood a seven months' siege, but the withdrawal of the besiegers was purchased only at the price of 1,000 pounds in gold.

Rome was shaken, but not crushed. Further Gallic raids were repulsed, and a treaty was made with the Gauls. Rome had become the leader among the states of the Latin League against the incursions of the Sabellian mountaineers. The Latin League grew restive as the Roman power increased, just as the Delian League had done when Athens became dominant. Many Latin cities rebelled ; the Romans broke up the league, and its cities became in 338 B.C. nominally allies, but actually subordinates of Rome, with varying degrees of independence. Meanwhile the Romans also engaged in a final struggle with the Sabellians, who under the name of Samnites were pressing upon the south-east of Latium and Campania. The Samnite Wars (343-290 B.C.) ended in a treaty which left the Samnites independent allies.

In the early days of the Latin League it became imperative for Rome to claim the right of controlling alliances and of deciding when to go to war or make peace. Equality disappeared ; cities were admitted to the League only upon conditions which constantly strengthened the position of Rome. Roman citizens were given freedom of trade, and in effect full rights of citizenship, in the other cities, but citizens of those cities were not allowed free access to Roman markets or the right of marriage into Roman families.

Rome and Her Allies

During the 4th century B.C. a gradation of privileges was developed. Some cities lost their individuality as states by simple enrolment of their freemen among the citizens of Rome—a privilege less substantial than it sounds, because only dwellers near Rome could take part in Roman political assemblies. The representative principle had not yet been evolved, and personal attendance was necessary. On the next grade were cities to which were granted all the ordinary civil rights of Roman citizens, without any political franchise. These came to be known as the cities with "Latin rights."

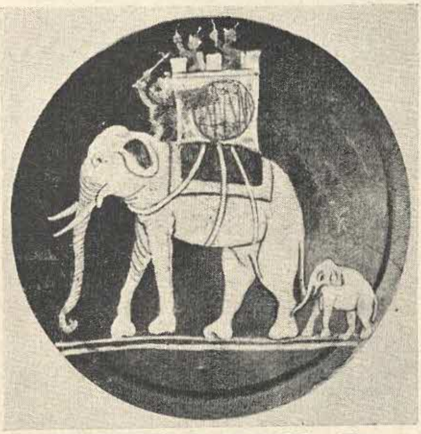
On a still lower grade were the cities which after the dissolution of the Latin League were allowed local self-government, but had neither

CELTIC RAIDERS. Among the most formidable enemies of early Rome were the Celts or Gauls. This fragment from an Etruscan frieze represents two Celtic raiders who have dropped their loot on being surprised by Roman pursuers.

the political franchise nor the civil rights of Roman citizens. Military organization and the making of war and peace remained in Roman control. The cities were guaranteed the protection of Rome, and given the prospect of further privileges if they rendered loyal service to the common cause. Later a yet lower grade was created of towns or (in the mountains) tribes directly governed by a Roman magistrate.

Distribution of land continued to be abused; public land rented from the state accumulated in the form of great estates held by a few individuals, and worked largely by slave labour, to the detriment of the free labourers. With every acquisition of territory, "colonies" of citizens were sent to serve as a garrison; this practice meant that many of the best of the yeoman class were removed to a distance from Rome. For a while, however, it helped to solidify Roman power.

The expansion of that power brought the city into touch with the Greek colonies of southern Italy, and, early in the 3rd century B.C., into direct collision with the city of Tarentum. The Tarentines invited to their aid Pyrrhus, king of Epirus, whose struggle with Antigonus Gonatas is mentioned in Lesson 13. Pyrrhus first met the Romans at the battle of Heraclea (280 B.C.); the struggle was fierce, and the Romans were defeated, chiefly by Pyrrhus's use of elephants. The Epirote army, however, suffered such casualties that the battle gave rise to the phrase "a Pyrrhic victory"; Pyrrhus is reported to have said that one other such victory would send him back to Epirus alone. Some of the Italian states became his allies, and he advanced to within 20 miles of Rome, but Roman preparations for defence were too strong for him, and he fell back southward.



ELEPHANTS IN EUROPE. The army that Pyrrhus led against the Romans in 280 B.C. was accompanied by war elephants. One is shown on this Italian platter.

In the following year he beat the Romans again at Asculum, but again at heavy cost. He agreed to a truce, and went to Sicily to help the Sicilian Greeks against the Carthaginians. There again he began with successes, but after a while received a severe repulse, and he quarrelled with the Sicilian Greeks. While he was transporting his army back to Italy a Carthaginian fleet destroyed some of his vessels. Pyrrhus resumed his offensive against Rome but was beaten at Beneventum in 275 B.C. He left Italy, and in 272 B.C. a Roman faction in Tarentum secured the surrender of that city.

LESSON 16

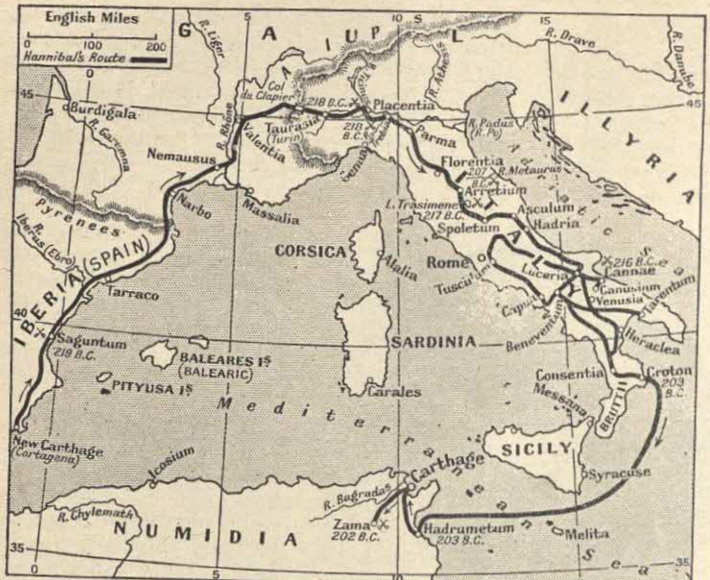
Death-Grapple of Rome and Carthage

In the north of Italy, between the Apennines and the Alps, were the free tribes of Nearer or Cisalpine Gaul; the Greek or Italian states in the south had been absorbed into the Roman Commonwealth or were dependent allies of Rome. During the Pyrrhic war Carthage had made an alliance with Rome. The next phase of Roman history brought the city into her long and savage conflict with Carthage for mastery of the western Mediterranean world.

Except in Sicily, Carthage had never attempted serious military conquest. The Carthaginians were sailors and traders, not soldiers; the state was an oligarchy of merchant nobles. Armies were raised for the most part from the African tribes, or hired from the African chiefs or kings of the Mediterranean littoral. Though the generals were Carthaginians of the ruling families, they were always suspected of designs to dominate the government or to seize power themselves. This suspicion and the consequent friction were sources of weakness.

The name "Punic" was another form of "Phoenician"; the Carthaginians were originally Phoenicians, who succeeded the Cretans as the great traders throughout the Mediterranean. Rome had no fleet and no maritime experience; Carthage was constantly seeking to establish new naval and commercial outposts. The occasion of their collision arose in Sicily, where the Mamertines of Messina asked help from Rome against besieging forces from Carthage and Syracuse. Roman troops relieved Messina; Hiero of Syracuse broke off his alliance with Carthage, and Rome engaged in the critical adventure of the First Punic War (264–242 B.C.).

The seaborne commerce of Rome and her dependencies was at the mercy of the fleets of



HANNIBAL'S ITINERARY. After capturing Saguntum in 219 B.C. Hannibal crossed the Pyrenees and marched along the south coast of Gaul and across the Alps into Italy. He won victory after victory, but was at length compelled by lack of reinforcements to withdraw to the peninsula of Bruttium, whence he was recalled to Africa.

Carthage ; Roman troops in Sicily were liable to be cut off from Italy. The Romans therefore built a fleet, provided with mechanical devices for breaking tackle, grappling, and boarding, to assimilate a naval engagement to a land battle. The result was that when an engagement could be forced the Romans won crushing victories, although they had to learn the whole art of seamanship in the course of a struggle with the most experienced seamen in the world. In the process both powers suffered appalling disasters. By 256 B.C., however, Rome had been able to send a great expedition to besiege Carthage itself. The Carthaginian army was commanded by Xanthippus, a Spartan ; he defeated and captured the Roman general Regulus, and the survivors of the Roman army were wrecked on their homeward journey.

For five years Regulus was imprisoned at Carthage. According to tradition he was sent to Rome under parole to return if he was unable to obtain peace ; arrived there, he urged the Senate to continue the struggle and leave him to his certain doom. He returned to Carthage and was barbarously murdered ; at Rome his wife was given two noble Carthaginian prisoners, one of whom was released by the consuls after she had starved the other to death. Rejecting Carthaginian overtures, the Romans made gigantic efforts—as, for instance, at Lilybaeum in Sicily, which they besieged for eight years in spite of naval defeats near by—and the skill of the Carthaginian commander Hamilcar Barca was not in the end sufficient to prevail. In 241 B.C. peace was made ; the Carthaginians evacuated Sicily and paid a heavy war indemnity. Syracuse retained her independence under Hiero, but the rest of the island was organized as a subject province of Rome.

Carthage was beaten, but not crushed. Threatened by Rome with a renewal of the war, the Carthaginians averted it in 238 B.C. by ceding Sardinia and Corsica. While the Romans gained control over Gallic and other tribes of northern Italy, and on the waters of the Adriatic Sea, Hamilcar, by an astute combination of war and diplomacy, established a Punic ascendancy among the Celtiberian communities in Spain, in order to secure there a base for operations for a final duel with Rome.

In 229 B.C. Hamilcar died ; his work was carried on first by his son-in-law, Hasdrubal, and then by his young son Hannibal (*c.* 247–183 B.C.) whose dominant passion was hatred of Rome. In 218 Hannibal led a great force of Carthaginians, Numidian cavalry, elephant corps, and Spanish tribesmen, past the Pyrenees, through southern Gaul, over the Alps (an almost incredible feat), and into Cisalpine Gaul.

Hannibal's Battles

Hannibal believed, mistakenly, that all Italy would rally to him against the tyranny of Rome. Instead, most of Italy remained stubbornly loyal. His genius and the devotion of his troops won victory after victory whenever he could force an engagement : on the Trebia, at Lake Trasimene, and finally at Cannae (216 B.C.), where a consul, dozens of high officials, 80 senators, and 60,000 other Romans were killed. The Romans, however, held on grimly, avoiding further battle ; Hannibal's army was too small for effective investment of the city. No supplies reached him from Carthage, and his army had to live on the country, which made the population the more hostile.

Victories of Scipio

On the other hand, as the war went on the Sicilian Greeks rebelled, Hannibal received some support from Tarentum, and Philip V of Macedon allowed Macedonian volunteers to take service at Carthage. In Spain, Publius Scipio (237–*c.* 183 B.C.) the young Roman commander,

HANNIBAL. Chief of the armies of Carthage.

allowed Hannibal's brother, another Hasdrubal, to slip through his fingers into Transalpine Gaul, whence he arrived with a strong force in Cisalpine Gaul in 207 B.C. If Hasdrubal had joined Hannibal, Rome might have fallen ; but the Roman commander Claudius Nero defeated and killed Hasdrubal at the Metaurus river. Hannibal's last chance of reinforcement was gone. Meanwhile the Sicilian revolt had been completely crushed.

In 206 B.C., while the war in Italy languished from the exhaustion of both sides, Scipio ejected the Carthaginians from Spain and opened negotiations with African princes. Next year Scipio was given the Sicilian command with the avowed purpose of carrying the war into Africa instead of attempting to crush Hannibal and his men in south Italy.

Carthage recalled her mightiest son to save the state from destruction, but Scipio was already in Carthaginian territory. Hannibal's army was no longer of the best quality ; at the battle of Zama (202 B.C.) he was completely defeated. Scipio was surnamed Africanus in honour of his victory. The Carthaginians ceded their Spanish and insular dominions and their fighting fleet to Rome, and were saddled with the payment of an enormous indemnity. Their commerce was left free, but they were incapacitated for naval or military action.

SCIPIO. Called Africanus after his great victory.

LESSON 17

The Supremacy of Republican Rome

WHEN, in 202 B.C., Carthage ceased to be a power, the Romans could not allow any other state to develop after the manner of Carthage, and thus to endanger her conquests along the shores of the Mediterranean. East of Italy were the three kingdoms of the heirs of Alexander : Egypt under the Ptolemys ; Syria under the Seleucids, whose reigning monarch was Antiochus III, the Great ; and Macedon under Philip V, a descendant of Antigonus, dominating the Greek states. Behind them were the barbarian Parthians. India and China were almost beyond knowledge. In the West there was now no power except Rome, the head of Italy, mistress of Sicily and the islands, and virtually ruler of the native states of the North African littoral. The next Roman objective was the conquest of the Hellenistic world of the Near East. The streams of Greek and Roman civilization were about to be united.

Campaigns against Macedon

In 202, Philip and Antiochus were planning a partition of the Egyptian dominions. The Greek states and leagues, in spite of violent dissensions among themselves, resented the domination of Macedon. In answer to an appeal for help; the Romans intervened, and defeated Philip at the battle of Cynoscephalae (197 B.C.). He was allowed to retain his kingdom as a vassal ; and amid wild enthusiasm the freedom of all the Greek cities was proclaimed at the Olympic Games. Antiochus of Syria, whose domains in Asia included most of Persia, tried to profit by Philip's defeat by seizing certain of the liberated cities. Encouraged by the exiled Hannibal and by Greek factions hostile to Rome, he invaded Greece, was defeated by the Romans, retreated to Asia Minor, was pursued thither, and was overwhelmingly defeated at Magnesia (190 B.C.). He was forced to surrender all claim to territory west of the river Halys, once the boundary between Lydia and Media ; Pergamum and Pontus became the two most powerful of the independent kingdoms of Asia Minor.

In 170 B.C. a new Macedonian war broke out ; the Romans defeated the new king, Perseus, at Pydna, and Macedon was turned into four vassal republics. In 149 B.C. Rome resolved to eliminate Carthage ; the excuse was that the Carthaginians had broken the treaty of 202 B.C. and had been goaded into war with Rome's ally, Massinissa of Numidia. In this, the Third Punic War, Carthage was taken (146 B.C.) by the army of the younger Scipio Africanus. The city was burnt and razed to the ground ; a plough was drawn over the site, and a curse pronounced against anyone who might try to rebuild on it.

In the same year perished the surviving liberties of Greece. The Achaean League had defied the orders of Rome ; Corinth held out to the bitter end and was destroyed ; the Macedonian republics had already been turned into a Roman province. Most of the Greek cities were placed under its governor ; later they were included in the new province of Achaea. In the course of the next twelve years revolts in Spain and Sardinia were crushed ; in 133 B.C., Scipio returned from

Spain to find Rome in the first throes of that breakdown of government which led to the civil wars and the end of the republic.

The expansion of Roman power involved new problems, new opportunities, and great strains on the capacity and morale of the governing class. Consuls and praetors—the magistrates next to consuls in rank—were sent out, after their term of office, as governors of provinces. They were then called proconsuls or propraetors, and during their governorships they became to all intents and purposes absolute rulers. The provincial legions were under their command; they and their officials had almost unlimited opportunities for personal enrichment at the expense of the provincials, and many of them took merciless advantage of their positions.

The armies in the East learned new luxurious habits. Roman farmer-soldiers who returned could not settle down to a simple life; the network of good Roman roads led them to swell the population massed in Rome. Many native Romans left the city to form military colonies, first in Italy and then in the provinces; the free population that remained had degenerated, yet that population alone still had the last say in political affairs. A growing evil was the number of slaves, needed for agricultural labour in place of the soldiers; conquest and piracy made them cheap.

Slave Revolts

Slavery is always degrading to both slaves and their owners; the evil done to the Roman character and institutions by the ownership and exploitation of slaves is plain enough now. There was much illegal enslavement, and much cruelty in the treatment of the enslaved. Savage slave revolts broke out in Sicily about 139 B.C. and again in 103 B.C. Less formidable risings took place in Italy; and, although all these were bloodily suppressed, slaves in their thousands later joined the rebellion of the Roman gladiators under the Thracian Spartacus, who in the years 73 to 71 B.C. beat army after army sent against him. He was defeated and killed at last in the heel of Italy; 6,000 of his captured followers were crucified along the Appian Way.

Meanwhile the Italian allies who had stood loyally by Rome resented her refusal to admit them to equal political rights; the Roman populace was jealous of any movement in that direction. All these factors contributed to rottenness at the core of the expanding republican dominion. Attempts at reform became inevitable. Rome under her old constitution could not control a world empire.

Reforms of the Gracchi

The tribune Tiberius Gracchus, member of a senatorial family, whose motives were those of a philanthropist rather than a statesman, set himself to remedy the agricultural grievance by re-enacting the laws against absorption of public lands, and by restoring those lands to their legitimate use. The wealthy classes found their prescriptive rights seriously endangered. Gracchus resorted to unconstitutional measures; they took the law into their own hands, and he was slain by a mob of senators (133 B.C.). Ten years later his younger brother, Gaius, took up the task more as a statesman than as a philanthropist. He realized the necessity of meeting the demands of the Italians; but he appealed to the populace by promising them a supply of corn at a fixed rate below the market value. He met with the same fate as his brother, and numbers of his followers were put to death. Almost the only achievement of his policy was the founding of a first regular colony outside Italy at Narbo Martius (Narbonne) in Transalpine Gaul.

The rift between the senatorial and populace parties widened; a war against Jugurtha, king of Numidia in Africa, was won by a plebeian general, Marius (157–86 B.C.), assisted by a brilliant subordinate, the aristocrat Sulla. Meanwhile, a new enemy threatened Italy and Rome; German tribes called Cimbri and Teutones burst into the province of Transalpine Gaul and overwhelmed Roman armies. Marius destroyed them in two great battles, and reformed the Roman military system by organizing what was virtually a permanent professional army.

STRIKING A BARGAIN IN THE SLAVE MARKET. In the second century B.C. conditions of slavery grew steadily worse. The traffic in human beings is illustrated in this bas-relief on a funeral stele from Capua. A naked man stands on a pedestal between a Greek dealer and a Roman buyer wearing the toga.

LESSON 18

The Triumph of Caesarism

THE Gracchi taught the plebs to look up to a leader; from their time dates the beginning of one-man authority in Rome. The leader to whom the people now turned was Marius, an able and honest soldier but no statesman, who although elected consul seven times failed to control his party in its struggle against the Senate and his principal rival and former lieutenant Sulla.

A new danger threatened from the East. Mithradates, king of Pontus on the Black Sea coast of Asia Minor, flung down a challenge to the Roman Republic. There was bitter party strife in Rome over the appointment of a commander in the East; the choice fell upon Sulla, who departed with his legions, leaving Marius and the popular party dominant in Rome. Large numbers of the senatorial party were proscribed and put to death. Marius was elected consul for the seventh time, but died shortly after.

Sulla and Pompey

Sulla, having vanquished Mithradates, returned with his legions to Italy, overthrew the demagogues after hard fighting, instituted a reign of terror, and reorganized the constitution. At the height of his power he chose to resign, and shortly afterwards died. His constitution had no permanence; it deprived the popular Assembly and the tribunes of power, conferring control upon the Senate, the body which had disastrously failed in the government of Rome since the Punic Wars. On the death of Sulla the two most powerful citizens of Rome were the wealthy Crassus and young Pompeius, later called Pompey the Great (106–48 B.C.), who had distinguished himself as a lieutenant of Sulla in the fight against Marius, and was sent in 76 B.C. to suppress a rebellion in Spain.

A brilliant orator, Marcus Tullius Cicero (106–43 B.C.), was rising to eminence among the moderates of the senatorial party, though his amiable personal ideals were by no means theirs. A young patrician, Julius Caesar (102–44 B.C.), who was also a nephew of the plebeian Marius, was now pushing his way to the leadership of the popular party.

POMPEY and CAESAR. Gaius Julius Caesar became supreme by defeating Gnaeus Pompeius (top) at Pharsalus in Thessaly, 48 B.C.

Pompey returned from subjugating Spain to find the senatorial party less ready than he expected to acknowledge his services. Against the wishes of the majority of the Senate he was given command in the East with virtually unlimited powers. Having destroyed the swarms of pirates who had dominated the whole eastern Mediterranean, he proceeded to conquer Asia as far as the Euphrates. He finally defeated Mithradates of Pontus, crushed the remnant of the kingdom of the Seleucids, made Syria a Roman province, captured Jerusalem, and brought the Jews under Roman control; in 62 B.C. he returned to Italy and dismissed his victorious army.

Meanwhile extremists of the popular party, headed by Catiline, a noble of evil reputation, plotted a revolution. Cicero, who was consul at the time (63 B.C.), discovered and crushed the plot, using unconstitutional methods more or less justified in the emergency. Caesar and Crassus were both accused of knowledge of the plot, and unsuccessful efforts were made to have Caesar proscribed. At this moment Pompey might easily have made himself master of the State, but he refused to overturn the constitution.

Rise of Caesar

Caesar, on the other hand, felt the time was ripe for a military dictatorship. To become dictator he required control of a number of the legions; the only way to secure this was to become a provincial governor. Caesar thus procured for himself the proconsulship of Gaul for five years, a period afterwards extended to ten. During those ten years Pompey showed small capacity in face of political chaos at Rome. Crassus was killed on an expedition against the Parthians, and the alliance between Pompey and Caesar broke down. Meanwhile Caesar proved his generalship by the subjugation of Gaul. He also paid two visits to the island of Britain, where he made no attempt at permanent conquest ; by extracting tribute, however, he was able to claim that he had added the island to the Roman dominions.

Caesar's successes inevitably alarmed Pompey, who was proconsul of Spain but had remained in Italy. Caesar, as proconsul of Gaul, had absolute command of the military forces in his province, but if he led his troops outside it he would be committing an act of rebellion against the Republic. The boundary of Cisalpine Gaul was the river Rubicon, far down the Adriatic side of what is now Italy. At the end of his term Caesar was commanded by the Senate to hand over his province and army. He agreed to do so on condition that Pompey did the same ; this condition was refused, and Caesar declared war by leading his army across the Rubicon (49 B.C.).

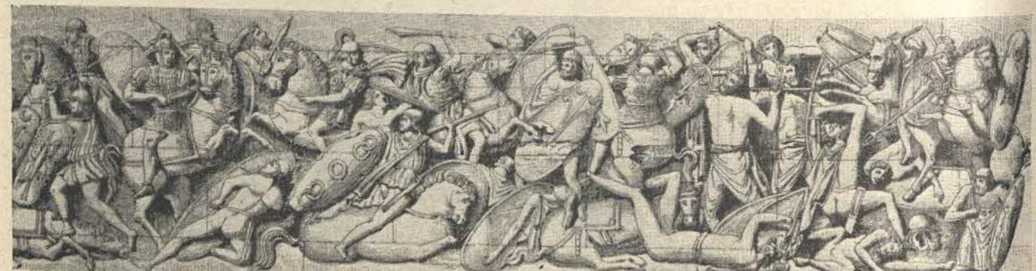
In Italy there were now no legions but his own ; Pompey withdrew to Greece to gather an army with which to crush the enemy of the Republic. Caesar made himself master of Rome and of the treasury, secured Spain, Sardinia, and Sicily, with hardly any fighting ; then he crossed into Thessaly, and routed Pompey's army at Pharsalus (48 B.C.).

Pompey fled eastward to raise fresh armies, but on landing in Egypt was assassinated by order of Ptolemy XII. Caesar marched on, crossed the Hellespont into Asia, and took ship to Alexandria, where after riots and fighting, and reinforcement by his ally Mithradates of Pergamus, he established Ptolemy XIII and Cleopatra (69–30 B.C.) as rulers. Cleopatra became his mistress, and later voyaged to Rome, where she was living when Caesar was murdered. Caesar went to Pontus, defeated the rebel Pharnaces (son of the other Mithradates, the former enemy of Rome), and returned by way of Athens to Italy. He combined vigour with leniency, and restored order there ; he went on to defeat Metellus Scipio and Cato, with their ally Juba, king of Numidia, at Thapsus in Africa. Caesar returned to Rome and celebrated triumphs over four countries—Gaul, Egypt, Pontus, and Numidia. He claimed no victory in the civil war, and led no Roman citizen captive. He finally crushed the sons of Pompey at Munda in Spain (45 B.C.).

During the four years of civil war Caesar had used his short periods at Rome to procure his own appointment as dictator for ten years, and to introduce various reforms, including that of the calendar, establishing almost with accuracy the exact solar year of 365 days, with an extra day in every fourth year. He had reorganized the system of provincial government, and had assumed authority to distribute all military commands. Now absolute master of the whole Roman world, he was the first emperor, although he had refused a crown and always used the republican title of dictator.

Assassination of Caesar

Caesar paid the penalty for leniency to political opponents. The dominion of one man was traditionally abhorrent to Romans, who did not understand that expansion and military dominion over most of the known world set too many problems to be solved by their republican form of government. Self-seeking politicians, and fanatical republicans who dreamed of the restoration of an oligarchy, combined in a plot against the dictator's life. Caesar was planning a campaign against Parthia ; in spite of warnings he took no precautions for his own defence, and on the Ides (the 15th) of March, 44 B.C., he fell beneath the daggers of his assassins, of whom the most notable were Cassius, Decimus Brutus (the ablest soldier among them), and Marcus Brutus, Caesar's friend, who saw himself as a patriot overthrowing a dangerous tyrant.



ROMAN versus GAUL. The bas-reliefs on the triumphal arch at Orange show that the Gauls of Provence in the first century B.C. fought in the " sagum " or coarse woollen garment worn like a plaid over the shoulder, and used long swords and large oblong shields.

LESSON 19

The Augustan Age of Roman History

WHEN Caesar fell, Mark Antony (83–30 B.C.), one of Caesar's trusted lieutenants, the youthful Octavian, or Octavianus, great-nephew and adopted heir of Julius, and another of Caesar's lieutenants, Lepidus, after some quarrelling and fighting united as a triumvirate to hold power and avenge the dictator. They had the support of the many legions which had served and loved Caesar.

Marcus Brutus and Cassius went to raise troops in the proconsulates in the East to which they had been nominated by the murdered Julius. Decimus Brutus was killed in the first scramble for power and command. The Senate could do nothing but ratify the position of the triumvirate as self-appointed commissioners for the reorganization of the state.

The triumvirs proscribed their political adversaries and personal enemies ; Octavian and Antony crossed to Macedonia and completely defeated Cassius and Brutus at Philippi, 42 B.C. Cassius and Brutus committed suicide on the field. The triumvirate divided the Roman world between them, Antony taking the East and Octavian the West ; Lepidus, much less powerful than his colleagues, was given the small province called Africa.

AUGUSTUS (63 B.C. – A.D. 14). Octavian, great-nephew and adopted son of Julius Caesar, received the name of Augustus after his defeat of Antony had left him master of the Roman world.

Antony and Cleopatra

Octavian settled down to consolidate his power in Italy. Antony went off to secure the East, and in Egypt met Cleopatra, who had fled from Rome and resumed her throne. Antony and she fell passionately in love, and but for her he might have crushed Octavian and made himself master of the world. When the inevitable quarrel between Antony and Octavian ended in war, the result of the great sea-fight of Actium (31 B.C.) hung in the balance until Cleopatra with her galleys took flight ; the infatuated Antony followed her. His fleet was defeated, and his cause was lost. In Egypt, Antony, deceived by a false report of Cleopatra's death, committed suicide. Rather than grace her conqueror Octavian's triumphal procession in Rome, Cleopatra followed Antony's example.

Augustus as Dictator

The battle of Actium was a decisive event in history. Lepidus having ceased to count, Octavian now stood alone at the head of the Roman world. On his return to Rome he resigned the exceptional powers entrusted to him, but the Senate at once decreed him a further ten years as dictator, with the understanding that the period would be renewed as often as might be deemed necessary in the interests of the state. Octavian accepted these conditions ; he received from the Senate the titles of Augustus (a term of dignity only) and Princeps, which might perhaps best be translated as President.

He was officially invested with the Imperium, or absolute control of all the armies of the state, hitherto enjoyed only by commanders in the field ; he stressed the civilian title of Princeps rather than the military title of Imperator, but the latter (which came to mean emperor in the sense of ruler) gradually took precedence. In popular parlance he and his successors were all called Caesar.

The powers of making treaties, of declaring war, and of offering or accepting terms of peace, were conveyed to him without destroying constitutional forms, by extending to him—first for a term of years and then for life—the tribunician powers in Rome and the proconsular powers in all the further provinces. The Senate continued to sit and to be in theory the governing body ; republican magistrates continued to be appointed, but were in effect the nominees of Augustus.

The new arrangement was officially at first a restoration of the Republic. Unlike Julius Caesar, Octavian respected republican institutions and did not wish to destroy them, but the shadow of dual government soon disappeared. The Princeps held too much power ;

the state became a military autocracy, and Octavian reappears in history as the Emperor Augustus.

The Praetorian Guard

The legions and other troops of the empire were all stationed in frontier provinces, with the exception of the imperial household troops, called the Praetorian Guard. The importance of this body of picked fighting-men cannot be exaggerated ; they were a symbol of what the new government stood for, and were soon to become the most important factor in its continuance. Under the Republic, armies raised in Italy were disbanded after each war, until in the last century B.C. commanders were granted bodyguards for their protection. The Praetorian formation was established when Augustus returned victorious and received the Senate's permission to retain his guards in Italy. The legions were sent back to the provinces ; their commanders were now appointed by and were responsible to the emperor alone. They, and all soldiers, renewed each year their oaths of allegiance to him.

Economic Reforms

Augustus was a practical reformer. He established a census of individuals and of property, introduced a new principle of taxation, which he based mainly on land and personal possessions, and abolished a large number of unequal and capricious imposts which bore heavily on the poor. The state accounts were kept with strict accuracy, and what would now be called an annual state budget was introduced. Augustus appointed the governors of state provinces, and personally arranged that provincial taxation was fairly imposed and properly accounted for. He took an interest in the municipalities, established police forces, and developed the system of municipal government.

THE PRAETORIAN GUARD were the household troops of the Roman emperors. Some of them are shown here with one of their "eagles" or standards.

THE WIFE AND STEPSON OF AUGUSTUS. Livia Drusilla (left) was the mother of the emperor Tiberius (right), here shown as a young man.

The "Augustans"

Augustus was a lover of literature, a patron of poets, historians, scholars, painters, sculptors, and architects. He built the Theatre of Marcellus and a fine open square for the assembly of the people. Public baths and other splendid buildings were erected by Agrippa, the able minister and friend of Augustus. From the emperor's residence on the Palatine Hill is derived the word "palace." A famous group of writers flourished under the patronage of Augustus or of his counsellor Maecenas ; they include Virgil, whose epic *Aeneid* expresses the noblest in the Roman character. Horace, Ovid, Propertius, Tibullus, and Catullus were notable poets, Sallust and Livy famous historians.

German Defeat of Varus

Augustus established the frontiers of the empire on the Rhine, the Danube, and the Euphrates. German tribes were pressing on the Rhine and Danube ; late in the reign of Augustus a great disaster befell a Roman army which had crossed the Rhine. Its general, Varus, allowed himself to be led into an ambush by the German chieftain Arminius (or Hermann). This defeat (A.D. 9) practically quenched any idea of conquest of Germany : it also excluded Germany from the unity of western culture and so marked a division which no subsequent event has quite eradicated.

The empire thus founded within these frontiers marks the centre of European development. All earlier history leads up to it, all later history spreads from it. An immediate effect of its establishment was a great relief to the provinces, which had for many years been atrociously misgoverned ; individual members of the Senate had an interest in the perpetuation of that misgovernment, being accustomed to make their fortunes during their term of office. The emperor had no such interest. Bad government continued, of course, but it was diminished ; and the greatest gift of the empire was an almost unbroken general peace which lasted within the frontiers from 31 B.C. to A.D. 180. What wars took place were mostly beyond the frontiers. Stability and good communications allowed Roman language, law, and culture to sink into the provinces, which, especially in the West, came to feel less conquered by, than part of, Rome.

Some years before the defeat of Varus there occurred in a distant Roman province perhaps the most tremendous event in the course of human history. That event was the birth of Jesus Christ, whose crucifixion by Roman soldiers at the instigation of Jewish priests took place at Jerusalem towards the end of the reign of the successor of Augustus. A number of years passed before the imperial government in Rome took any interest in the newly-founded sect of Christians.

Death of Augustus

Augustus died A.D. 14, at the age of 76. He had ruled Rome for more than 40 years, and his reign was probably the happiest and the most prosperous period of imperial Rome. He had married three times, but left no son to succeed him.

His daughter's sons died in their youth, and the obvious heir to the Principate was Tiberius (42 B.C.–A.D. 37), the stepson of Augustus, his last wife's son by a former marriage.

LESSON 20

The Caesars from Tiberius to Marcus Aurelius

When Tiberius succeeded to the Principate or Empire of Rome in A.D. 14, he was an experienced soldier and administrator. In the service of his stepfather Augustus he had campaigned in what is now Germany, and he was opposed to any further expansion of dominion beyond the lines of the rivers. He ruled with a strong hand ; his legates and procurators knew that they would be called to strict account, regardless of wealth or family connexions, if they misconducted themselves seriously.

He despised the Roman populace and withdrew their right of voting to elect magistrates (under Augustus these elections had become a farce), and he economised in expenditure on public amusement. Consequently he made himself very unpopular in Rome. The prestige of Roman arms was maintained on the frontiers by his half-nephew Germanicus, who campaigned with success if without lasting effect among the German tribes.

The historian Cornelius Tacitus (*c.* A.D. 55–*c.* 119) wrote of Tiberius as a tyrant, cruel, greedy and revengeful, and in Rome and Italy the later part of the reign was almost a nightmare. Modern historians tend to see in Tiberius a man soured by harsh treatment from Augustus, and still more embittered by later misfortunes in his own family.

The popular general Germanicus, whom Tiberius recalled from Germany, died while on an eastern tour ; the emperor was suspected of having had him poisoned. Plots against Tiberius were made in Rome ; spies and informers flourished by denouncing real or imaginary plotters. Grounds for prosecution on charges of treason under the Republic were extended under the Empire. "Words," says Tacitus, "now became sufficient evidence of guilt ; overt acts were no longer necessary

TIBERIUS. The morose and tyrannical Tiberius (42 B.C.–A.D. 37) ruled with a firm hand. On this cameo he is shown with his empress ; in the heavens appears the deified Augustus.

for conviction." There was a general sense of insecurity among the rich and prominent. Tiberius withdrew to the island of Capri, where he was reputed to live a life of debauchery. He left Rome in the charge of Sejanus, the prefect of the Praetorian Guard; when Sejanus plotted to make himself emperor the plot was discovered, and Sejanus and his family were seized and executed (A.D. 31). In the 23rd year of his reign (A.D. 37) Tiberius himself fell ill and was murdered.

CLAUDIUS I (10 B.C.–A.D. 54) attached Britain to the empire.

Caligula the Cruel

As Tiberius had lost his son, his successor, chosen by the Praetorian Guard, was Gaius Caesar, the son of Germanicus, known as Caligula (A.D. 12–41); this nickname, meaning "little boot," was given him as a child by his father's soldiers. Not long after he became emperor Caligula had a severe illness which unsettled his reason; his name has become a byword for insane tyranny. The grotesque horrors of his rule were ended by the Praetorians, who murdered him and with some derision acclaimed as his successor his uncle Claudius, a pedant not without ability, but untrained in public affairs.

Claudius and the Empire

When he came to the throne, in A.D. 41, Claudius was 50; timid in character, he yet proved to be a statesman. He accomplished much for the Empire; among his improvements to Rome itself were aqueducts by which the city was plentifully supplied with water from the mountains. In A.D. 43 his general Aulus Plautius began the conquest of Britain; in 42, Claudius himself visited the island. Elsewhere the frontiers of the Empire were efficiently guarded.

At home, however, Claudius fell under the influence of his wife, Messalina, whose name has become a synonym for female profligacy and cruelty. At last her iniquities led to her destruction; Claudius took for his second wife Agrippina, sister of Caligula, a woman as merciless as Messalina. Agrippina's object was to secure the succession for Nero, her son by a previous marriage. When Claudius died in A.D. 54, probably as a result of poison, the boy Nero (A.D. 37–68) became emperor. He was descended on both sides from the ill-fated family of Augustus.

For a time the government was carried on by regents, one of whom was the poet and philosopher Seneca. When Nero himself took control he soon displayed the qualities which have made his name a byword for vice and savagery; his own wife Poppaea, and his mother Agrippina, were among the many victims of his rage and suspicion. As artist and athlete he wished to excel; he composed verse and music, and displayed great skill as a charioteer.

Reign of Nero

His reign was marked by a terrible persecution of the Christians, which he endeavoured to justify by accusing them of having caused in Rome a fire which consumed half the city, while, according to tradition, Nero looked on and played the fiddle. At great expense he rebuilt the city; the palace of Augustus having been practically destroyed, Nero erected for himself another, called the "Golden House."

British Revolt under Boadicea

During his reign took place the British rising under Boadicea, widow of the king of the Iceni, a people occupying the country now called Norfolk and Suffolk. When Boadicea's husband died, he left his kingdom jointly to his daughters and to the Roman emperor, hoping thus to secure it from harm; but Roman officials seized the whole territory and ill-treated the queen and her children. Boadicea escaped, raised a large army, and wiped out the Roman colonies at the places now called Colchester, St. Albans, and London. The Roman governor of the island was with his army in Anglesey; returning, he defeated the Britons, and Boadicea committed suicide (A.D. 62).

NERO (A.D. 37–68). His reign degenerated into a monstrous tyranny.

Nero's excesses and tyranny had their inevitable result. The legions in the west declared for their general, Galba—"a man," says Tacitus, "whom all men judged fit to be emperor, had he never been emperor." Galba marched on Rome from Spain; the Praetorians deserted Nero, who fled from the capital and shortly afterwards committed suicide (A.D. 68). Nero was the last ruler of the line of Augustus; thenceforward the succession was frequently contested, and seldom held by one family for more than a few generations. Galba displayed small capacity; Otho, a former friend of Nero, led a military revolt, and Galba was deposed and killed after a reign of only six months.

Vitellius

Vitellius, a popular commander of the legions on the Rhine, was proclaimed emperor by his own army ; he marched to Italy, defeated Otho in a decisive battle, and took his place for a few months. Meanwhile, Vespasian, who commanded in Syria, also decided to make himself emperor ; engaged at the time on the siege of Jerusalem, he left his son Titus to capture the city, and returned to Rome. Vitellius had been murdered by the time Vespasian arrived. Vespasian was a man of humble parentage, with a great capacity for leadership. During the conquest of Britain he had commanded the Second Legion, and among his successes was the storming of Maiden Castle, the hill fort in Dorset.

VESPASIAN (A.D. 9–79) was proclaimed emperor in the East by his soldiers.

Vespasian and his Sons

As a soldier Vespasian had no living rival, and the army was loyal to him. Titus captured Jerusalem and dispersed the Jews. Agricola completed the conquest and provincial organization of Britain. Vespasian was also a shrewd man of business, whose rule in some ways resembled that of Henry VII of England. He removed many corrupt officials, and re-organized the financial system, which was in utter confusion ; he restored the Capitol, which had been reduced to ruins by fire during the recent war ; he began the building of the Colosseum, and he established a great public library. Legend tells that during his last illness, in A.D. 79, he said "an emperor should die standing up."

Destruction of Pompeii

The only notable event of the brief reign of Vespasian's elder son Titus was a tremendous eruption of Vesuvius in August, A.D. 79, which overwhelmed with ashes or lava several neighbouring towns, including Pompeii and Herculaneum. The site of Herculaneum was rediscovered in 1720 ; remains of many of its buildings were excavated. Pompeii stood farther away from the burning mountain and was not so much destroyed by lava as preserved by ashes ; but Pompeii also was completely hidden for many centuries.

Titus was succeeded by his brother Domitian. During the earlier part of his reign Domitian showed promise of good rule, but his was a weaker character than that of Vespasian or Titus ; the corruption of absolute power set in rapidly. Great expenses entailed oppressive measures ; conspiracies were answered by cruelties which became wanton and vicious. Tacitus and Juvenal have left descriptions of Roman life under this half-crazy despot. A palace conspiracy brought his life and reign to an end in A.D. 96.

Nerva and Trajan

The Praetorian Guard permitted the Senate to choose as emperor Nerva, an elderly civilian. Nerva strengthened his position at once by adopting as his junior colleague and heir the capable and successful Trajan (A.D. 53–117), commander of the legions on the Rhine. Nerva reigned for only two years. News of Nerva's death and of his own succession reached Trajan at Cologne ; for some months he continued his work on the frontier, ensuring peace and improving army discipline; then he returned, and entered Rome on foot, with his empress, the admirable Pompeia Plotina, at his side.

Trajan was well qualified for the imperial dignity. He at once undertook important reforms, reducing taxation and selling some of

TRAJAN IN THE FIELD. This scene from Trajan's Column in Rome shows the emperor, during his first campaign against the Dacians, at the head of his division on the north bank of the Danube.

the palaces confiscated by his predecessors. He spent public funds for the benefit of the poor, restored to the Senate much of its lost power, and promoted public works, partly as a means of finding work for the unemployed. The making of roads, the draining of marshes, and the creation of new seaports were sometimes undertaken at his own expense.

Trajan and the Christians

He founded a library, and caused the erection of splendid public monuments, among them Trajan's Column. Especially noteworthy is his "rescript," or instruction, to the provincial governor Pliny concerning the treatment of Christians. They were not to be hunted down, but those who persistently refused to sacrifice to the Roman gods before the image of the emperor must suffer the penalty of high treason. Christians were supposed to practise barbaric and magical rites which could not be tolerated by a civilized government ; the Jews were the only people privileged to refuse conventional worship.

Besides being a great ruler, Trajan was a soldier who extended the bounds of the empire. He conquered beyond the Danube the province he named Dacia, and brought various Asiatic regions under the sway of Rome ; he is said to have declared that if he were a younger man he would undertake the subjugation of the Indies. He died while campaigning in the East, in A.D. 117, after a reign of nearly 20 years ; he left no son, but had nominated as his successor his kinsman Hadrian.

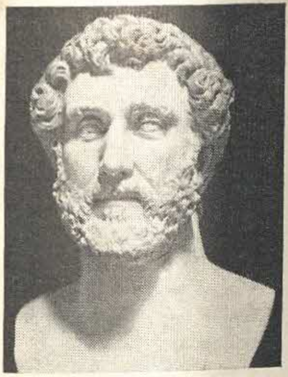
HADRIAN (A.D. 76–138), represented here by a bronze head found in the Thames. He built the famous wall to keep the Picts out of Roman Britain.

MARCUS AURELIUS (A.D. 121–180). Succeeding Antoninus Pius in 161, he was "philosopher king" of the Roman world. This relief shows him receiving the submission of barbarian chieftains.

Hadrian

Hadrian (A.D. 76–138) spent much of his reign in travelling through his dominions, gaining close personal knowledge of their conditions. He tried to preserve peace with foreign states, and attempted no further conquest ; but he guarded the frontiers already won, and in Britain he built the great wall from the mouth of the Tyne to the Solway Firth, some fragments of which still survive. Many public works were constructed during his reign. He died in 138.

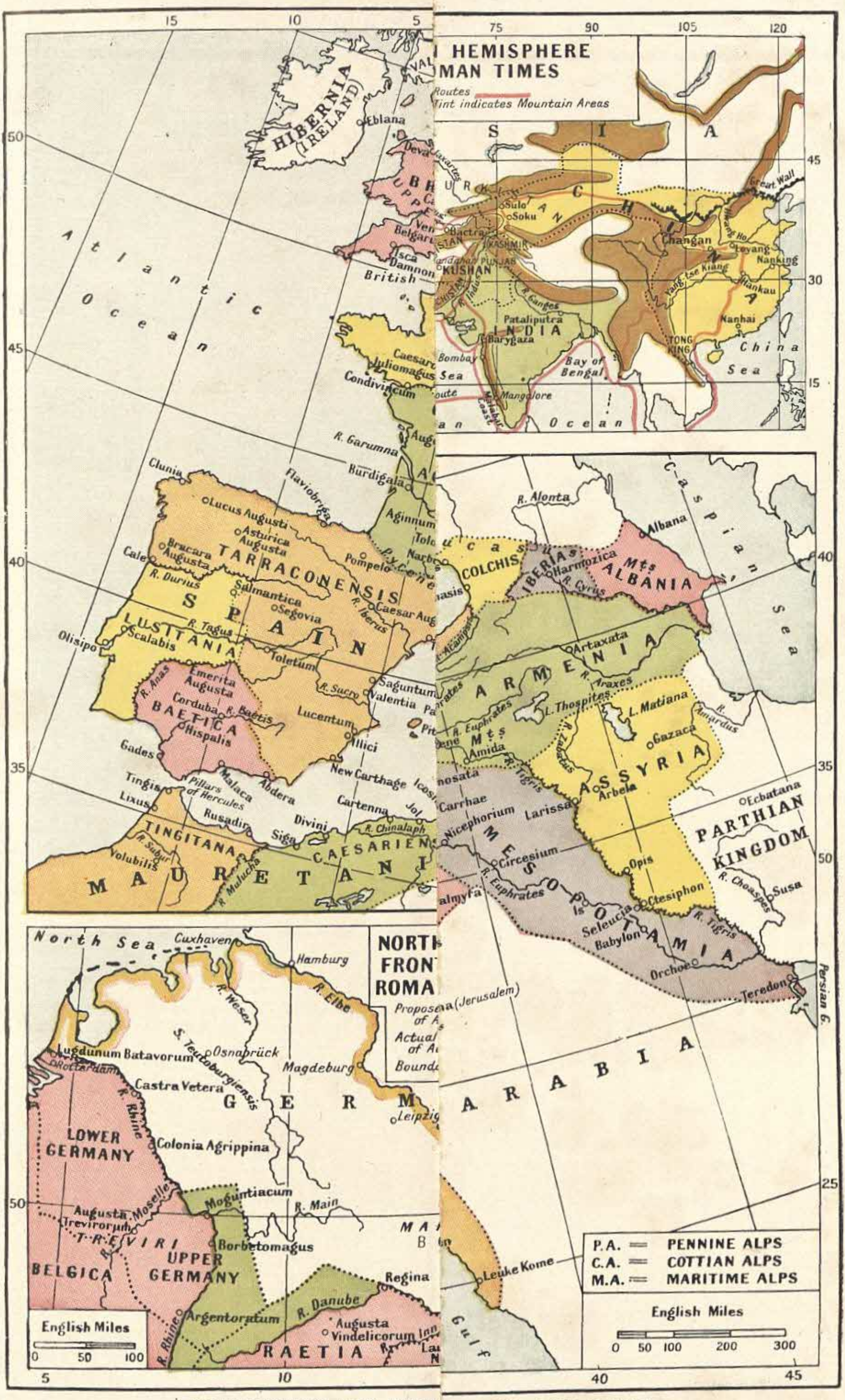
Hadrian named as his successor Antoninus Pius, whose grateful people gave him the title "Father of the Human Race." He was the first Roman emperor who discouraged persecution of the Christians. His reign was peaceful, apart from suppression of disorders on the frontiers. He died in his 75th year, leaving as his successor Marcus Aurelius, whom he had adopted. The new emperor, Marcus Aurelius (121–180), was a philosopher ; his *Meditations* show a curious unconscious approximation to the Christian ethic, though he persecuted the Christians, being misinformed as to their tenets.



ANTONINUS PIUS (A.D. 86–161), adoptive son of Hadrian. Called by the Romans the "Father of the Human Race."

Reign of Marcus Aurelius

His reign was troubled by incessant conflict with Teutonic tribes on the frontier ; earthquakes devastated parts of Italy, and pestilence raged for a long time in Rome. Marcus, although by nature and inclination a student, ruled with a high sense of duty, and devoted himself unswervingly to the welfare of his subjects. He died in 180, during a campaign.



BOUNDARIES AND PROV O INDIA AND CHINA

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LESSON 21

Caesars by Grace of the Legions

COMMODUS, the degenerate son of Marcus Aurelius, was assassinated in A.D. 192. Two hundred and twenty-three years had then passed since Augustus became master of the Roman world. Caesar had followed Caesar—officially by choice of the Senate, though Caligula, Claudius, and Vespasian had been chosen by the soldiery. Vespasian and most of his successors had appointed their own heirs. Theoretically, each Caesar was the Princeps, the first magistrate for life of the Roman Republic ; the fact that the basis of his power was in the Imperium, the supreme command of the armies, was never emphasised. After Commodus the Princeps was merged in the Imperator.

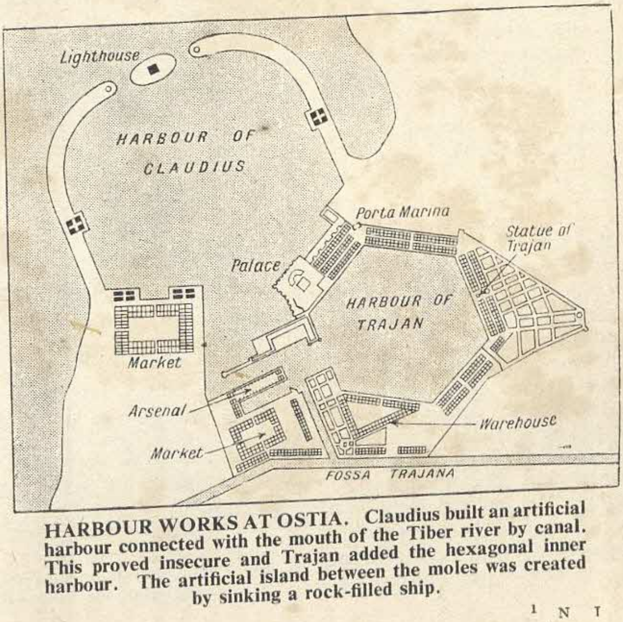
Except Trajan, who was a Spaniard, all the emperors had also been of Roman or Italian descent. After Commodus a Roman was a rarity. Roman citizenship was still necessary for service in the legions, but the extension of that citizenship had gradually widened the area of recruitment of the rank and file. Moreover, the legions were now supported by auxiliary troops levied from the non-Roman populations of the Empire. These were mercenaries, often barbarians, commanded by men from their own provinces or frontier lands; commanders of the legions themselves began to be other than Romans. The main armies, each with its own commander-in-chief, were those of Syria, and Asia (Minor), of the Danube, of the Rhine, Britain, and Spain. In Italy the Praetorian Guard continued to be the only troops.

Hitherto, then, Caesars had ruled with the approval of a subservient Senate, unless they had made themselves personally intolerable and had fallen to public or private vengeance. Within the bounds of the Empire the Roman peace had been upheld, though fighting on one or other of the frontiers had not often altogether ceased. In the provinces and in Italy the administrative machinery worked. At sea there was comparative freedom from pirates. Travellers could take ship from the harbour of Claudius at the mouth of the Tiber and reach Spain or Athens in a week. Government ships carried passengers and goods between Alexandria and Rome. In summer this voyage took ten days; in winter traffic was stopped.

Several emperors were famous for legislation and public works. During the reign (A.D. 69–79) of Vespasian, Rome surpassed Alexandria in the grandeur and number of its public buildings. Magnificent new fora were laid out near the old Forum ; eventually there were four altogether, and in them the business of the capital was transacted. Between the two great libraries Trajan built his column, of Parian marble, on which were carved scenes from his campaigns.

Roman Culture

There was a large educated public in the Rome of Trajan's day. State libraries were open to all, and many craftsmen, soldiers, and slaves could read and write. The last great scientist of the ancient world, the geographer and astronomer Ptolemy (flourished A.D. 127–151), lived at Alexandria during the reigns of Hadrian and Antoninus Pius. Rome became the centre of the Mediterranean world, attracting men and religions from many parts ; but she grew at the expense of the rest of Italy. Large numbers of the agricultural population moved to the city. The land was neglected, the business of cities throughout the Empire declined, prosperous rural communities were so reduced that city industrial concerns could no longer sell their output. Curtailed production resulted in unemployment. Love of display increased ; vast sums went out of Italy to purchase luxuries—pearls, precious stones, silks, and choice fruits from the Orient. Many of the gold and silver mines around the Mediterranean seem to have



HARBOUR WORKS AT OSTIA. Claudius built an artificial harbour connected with the mouth of the Tiber river by canal. This proved insecure and Trajan added the hexagonal inner harbour. The artificial island between the moles was created by sinking a rock-filled ship.

ARCH OF SEVERUS. This famous arch was built in A.D. 203 in memory of the emperor's campaigns in Parthia, A.D. 198–202. On the face towards the Forum are shown Severus haranguing his troops, a Roman victory, and the capture of a Parthian town.

been worked out, and shortage of these metals for coinage hampered trade. Taxation burdened the provinces, and their own cultures declined.

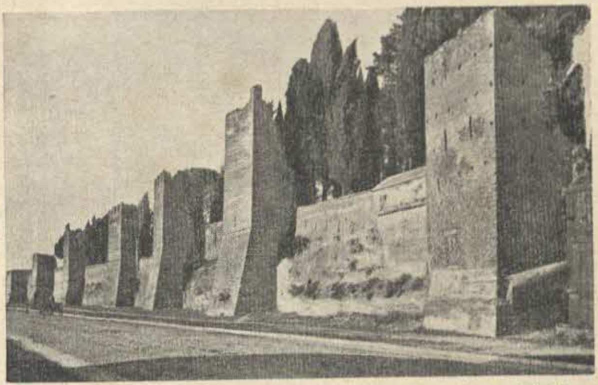
For more than a century no one except Trajan had attempted aggressive expansion, and Hadrian relinquished most of what Trajan acquired. In the east the Parthians were a constant danger; warlike tribes, Germanic or Scandinavian, pressed in increasing numbers on the Rhine and upper Danube. The Roman peace of more than two centuries came to an end. After the assassination of the emperor Commodus (A.D. 192) a struggle among several military usurpers finally set Septimius Severus (A.D. 146–211) on the imperial throne. Severus had been the commander on the Danube frontier; he disbanded the Praetorians, organized a new Praetorian Guard, marched against an eastern rival and slew him, and crushed another who advanced from the Rhine in a desperate battle near Lugdunum (Lyons). The new emperor had risen to high command by sheer ability. The remaining 14 years of his reign were peaceful within the Empire; Severus spent most of his time campaigning against the Parthians or in Britain, where he marched far into what is now Scotland. Domestic administration he left in the hands of the lawyer Papinian, who established the doctrine that absolute powers were vested in the emperor. Severus died at York in A.D. 211. In 212 his son and successor Caracalla (A.D. 188–217) granted citizenship to all free men throughout the provinces of the empire.

In the next 73 years there were 25 emperors, of whom only one died in his bed. Caracalla began by murdering his brother, and was assassinated in the sixth year of his nightmare rule. The troops made his boy cousin Elagabalus (205–222) emperor—a dissipated creature whose vices and cruelty made his name (often misspelt Heliogabalus) a by-word. He, too, was assassinated, and succeeded by a boy cousin, Alexander Severus (205–235), who showed promise but was killed in a mutiny. Among others in a rapid succession may be noted Philip the Arabian (244–249), who is reputed to have been a Christian; Decius (*c.* 201–251), a

A CAESAR IN THE DUST. This rock carving from Naksh-i-Rustam, near Persepolis, shows the Persian monarch Sapor I receiving in A.D. 260 the submission of the Roman Emperor Valerian, defeated near Edessa.

member of a once distinguished Roman family, who was a great persecutor of the Christians and was killed fighting against the Goths, now swarming down on the Danube ; Valerian, who marched against Sapor, king of Persia (Parthia had passed under the sway of a Persian dynasty), but was taken prisoner near Edessa and died in captivity (260) ; and the Illyrian Claudius II, who inflicted a heavy defeat on the Goths before dying of the plague (270).

Sixty years had now passed since the death of Severus. The three last-named emperors had rendered good service to the Empire, but their three reigns together covered only 11 years. The successor of Claudius was Aurelian (270–275), who beat back the Germans on the Rhine, made terms with the Goths, whom he settled in Dacia, and suppressed the independence of Palmyra on the Arabian border, where the famous queen Zenobia ruled with the philosopher Longinus for her minister. Aurelian restored some order in the empire, but fell victim to a private conspiracy. He built around Rome that massive wall, part of which stands to-day. Then, in 284, the death of an emperor while campaigning in the east led the army there to choose from its chiefs the Illyrian Diocletian, who had risen from the ranks by sheer force of ability and character.



AURELIAN'S WALL. Aurelian began new walls to defend Rome in 271 ; they were completed under Probus in 280. They were more than twelve miles in circuit and 60 feet high externally ; built of brick-faced concrete, they had massive towers at intervals of about 15 yards. Parts still exist.

Diocletian (emperor 284–305) was a soldier of genius and also a great statesman ; caring nothing for precedent or Roman tradition, he realized that the imperial centre of gravity had shifted from Italy to the East. He chose a trustworthy colleague, Maximian, to share with him the title of Augustus and to take charge of the western half of the Empire while he himself controlled the eastern half.

After a time Diocletian carried division or devolution a step further, and appointed for each Augustus a sub-emperor or Caesar—Galerius in charge of the Danube provinces, Constantius Chlorus in charge of Britain, Gaul, and Spain ; but all three of these colleagues were responsible to himself as the senior Augustus. The four great realms were subdivided into " dioceses " each with its lieutenant-governor, and the dioceses into provinces. This pyramidal arrangement was applied alike to both civil and military administration ; one of its important features was the permanent severance of civil from military functions.

Diocletian orientalised and militarised the state ; in the 21st year of his reign, when his system had proved itself, he and Maximian abdicated, after appointing the two Caesars as the new Augusti. Galerius, the senior, nominated the new Caesars. By fixing his own headquarters at Nicomedia, in Bithynia, Galerius prepared the way for Constantine's transfer of the capital of the Empire from Rome to Byzantium. Diocletian and he were responsible for the fiercest persecution of the Christians.

LESSON 22

New Rome at Constantinople

Constantine the Great is commonly regarded as the second founder of the Roman Empire. Diocletian has the better right to the title ; with one important exception, Constantine carried forward Diocletian's reconstruction, which had reduced Italy to the status of a taxed province and shifted the centre of power to the East. Constantine changed the method of succession, which Diocletian had instituted to meet an emergency ; but Diocletian created the bureaucratic administration that held the empire of the Caesars together in its Byzantine form, enabling it to survive for eleven and a half centuries after his abdication.

The succession as dictated by Diocletian very soon broke down in confusion. The half-barbarian Galerius had no personal ascendancy. He and Constantius became Augusti, but Constantius died in 306, and his son Constantine notified Galerius that he had been obliged to accept his army's nomination as his father's successor. Galerius could only ratify his accession as junior Caesar ; the eastern Caesar was his own nephew Maximin, and he

CONSTANTINE (A.D. 288–337) made himself sole emperor and built Constantinople.

nominated the western Caesar, Flavius Severus, to be western Augustus. The Roman Senate, however, tried to assert authority by proclaiming Maxentius, the son of Maximian, as western Augustus. Maximian came out of his reluctant retirement to support his son's claims. Flavius was captured and put to death ; Maximian reclaimed the title he had resigned. Galerius attempted an invasion of Italy, but thought better of it, retired, and nominated as second Augustus an old comrade-in-arms, Licinius.

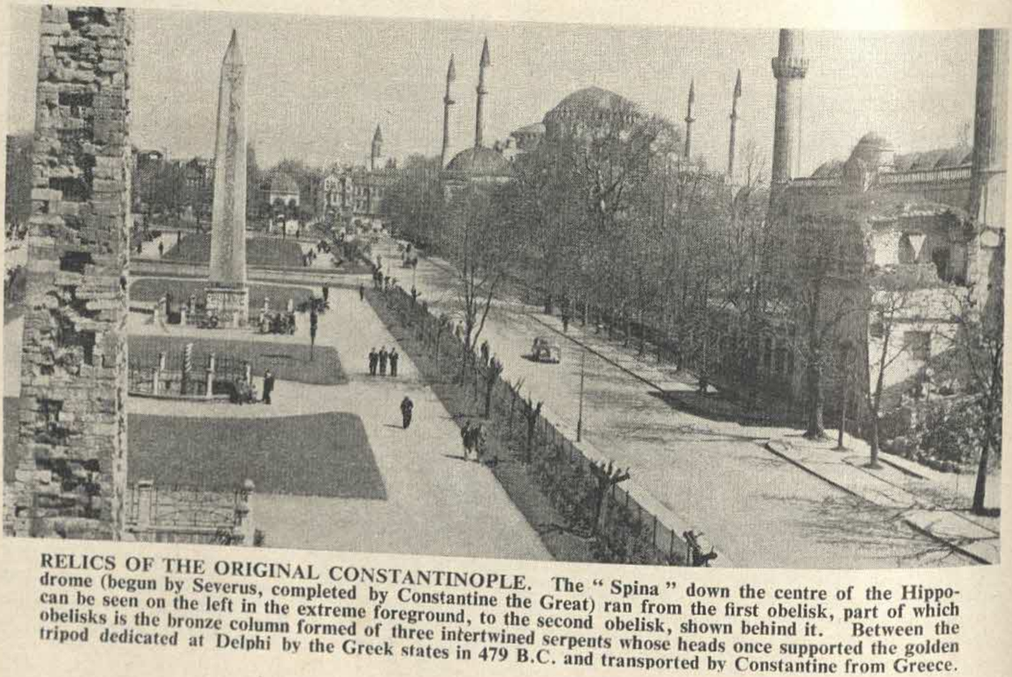
Maxentius and his father quarrelled ; Maximian allied himself with Constantine, who accepted from him the title of Augustus and the hand of his daughter Fausta. From 308 the Roman world was for a while ruled and disputed by six emperors ; in the West Maximian, his son Maxentius, and his son-in-law Constantine ; in the East Galerius, his nephew Maximin, and his friend Licinius. In 310 Maximian and Constantine fell out : Constantine captured Maximian at Marseilles and compelled him to commit suicide.

In 311 Galerius died at Nicomedia in Asia Minor ; Maxentius and Maximin secretly allied themselves, and Constantine and Licinius came to an agreement. Maxentius ruled Italy and Africa, turned on the Roman Senate, instituted a system of " free " gifts to himself which enabled him to plunder his subjects without mercy, and prepared to invade Gaul ; but Constantine, a brave and skilful soldier, forestalled him by invading Italy.

At the battle of the Milvian Bridge (312), near Rome, Maxentius was completely defeated; he himself was drowned with thousands of his men. The Praetorian Guard stood its ground and was all but annihilated ; Constantine destroyed its fortified camp and abolished the corps itself, thus removing the main defence of the city of Rome. He declared that while on the march he had seen in the sky the vision of a flaming cross with the words " In Hoc Signo Vinces " (in this sign thou shalt conquer).

Now undisputed Augustus in the West, he issued from the imperial headquarters at Milan the famous decree which made of Christianity an officially authorised religion (313). Licinius published the decree in the East. Licinius and Maximin quarrelled ; Maximin held Constantinople for a few days, then fled into Asia Minor, and died or was murdered. The inevitable conflict between the two surviving emperors was postponed until 323, when Licinius was decisively beaten and put to death. Constantine became sole master of the Roman world.

Constantine reigned alone for nearly 14 years. He maintained the territorial divisions of



RELICS OF THE ORIGINAL CONSTANTINOPLE. The " Spina " down the centre of the Hippodrome (begun by Severus, completed by Constantine the Great) ran from the first obelisk, part of which can be seen on the left in the extreme foreground, to the second obelisk, shown behind it. Between the obelisks is the bronze column formed of three intertwined serpents whose heads once supported the golden tripod dedicated at Delphi by the Greek states in 479 B.C. and transported by Constantine from Greece.

Diocletian, but he substituted for the two Augusti and the two Caesars four civil prefects holding no military power, and four pairs of military chiefs, masters of foot and of horse respectively, all directly responsible to the emperor. He designated his sons (of whom the eldest was 20 when Constantine died) as his successors with the courtesy title of Caesar. His armies dealt successfully with the barbarians on the frontiers ; at the end of his reign he was planning a campaign against Persia, whose renewed threats of aggression ended a long truce.

THEODOSIUS AT THE GAMES. This bas-relief on the pedestal of an obelisk in Istanbul, erected by Theodosius, shows the emperor watching the games in the Hippodrome.

He gave to the imperial court, now permanently established in the East, that oriental character which thenceforth it retained. The two outstanding features of his rule were the development of the old trading town of Byzantium into the imperial city and fortress of Constantinople (" Constantine's city "), and the virtual, though as yet informal, establishment of Christianity as the official religion of the Empire.

In six years the city of Constantine was transformed into the most magnificent capital the world had known ; its formal dedication in 330 is a milestone of history. In 324 Constantine confirmed the Milan decree with an edict of toleration, and in the following year presided in person over the universal council of the Christian Church (which in spite or in consequence of persecution had long been a highly organized body) held at Nicaea.

At this council was affirmed what came to be the orthodox doctrine of the Holy Trinity as against the heresy of Arianism ; its decisive victory over various heresies, particularly the Arian (i.e. that upheld by the theologian Arius), was still long deferred. Constantine was not a professed Christian ; he and his successors for fifty years to come held the office of Pontifex Maximus or chief priest of the old pagan religion, even after baptism. But from that time the Church was a power within the state and in close association with the government.

TRIUMPH OF THEODOSIUS. This famous shield, an engraving on silver, shows Theodosius the Great enthroned with his son Arcadius and with Valentinian II.

When Constantine died, in 337, his eldest son Constantius succeeded. Constantius was occupied for 12 years with the Persian war, chiefly in Mesopotamia. Meanwhile his two younger brothers quarrelled for supremacy in the West. Constans defeated and killed Constantine II, and was killed by his own general, Magnentius. Magnentius claimed the empire; Constantius patched up a truce with the Persian king Sapor II, overthrew Magnentius, and in 356, being recalled to the East by Sapor's renewed activity, sent his young cousin Julian as Caesar to Gaul. Julian fought brilliantly against the invading Franks and Alemanni ; but he was already in arms against Constantius when the latter died in the East.

Julian the Apostate (*c.* 331–363) is famous chiefly for his attempt to revive a mystical paganism grafted upon Stoicism ; he had reigned only two years when he died in the course of a whirlwind campaign against Sapor. After a brief interval the legions elected a soldier, Valentinian I, who sent his brother and co-emperor Valens to the East; frontier conditions made divided command a necessity. For 12 years Valentinian fought victoriously against the Germans on the frontier, and on his death was succeeded in the West by his young son Gratian, whose child-brother Valentinian II was also named as Caesar.

While Valentinian I held the Germans in the West, Valens in the East failed to prevent Sapor from conquering Armenia. Beyond the Danube frontier the Goths, long settled in Dacia, were hard pressed by a new and formidable foe, the Huns migrating from Central Asia. They appealed to Valens, who allowed them to cross the river into Moesia. Their numbers alarmed him, and his suspicious policy goaded them into revolt. Valens sent for aid to Gratian, but did not wait for him to arrive. At the epoch-making battle of Adrianople (378) the Romans were overwhelmed and Valens was slain. Gratian retreated, nominated Theodosius as successor to Valens, and was himself overthrown and murdered by Maximus, an ambitious general from Britain.

Theodosius claimed Italy for the boy Valentinian II, while recognizing Maximus in Gaul. When Maximus a little later attacked Valentinian, Theodosius had strengthened his own position and was able to destroy Maximus. His patient diplomacy, aided by revival of the dissensions customary among the Goths, enabled him to enlist them as allies instead of fighting them. Valentinian was assassinated by his Frankish general Arbogast, who set up a puppet emperor ; Theodosius crushed the rebels, and in effect ensured the partition of the Empire by nominating his elder son Arcadius as his own successor in the East and appointing the younger, Honorius, at once to the throne of the West. Theodosius attached himself to the orthodox Church which held to the Athanasian creed. Pagan rites were sternly prohibited, and Christianity was accepted as the state religion. In 395 Theodosius died ; and the Roman Empire was never united again.

LESSON 23

Barbarian Invaders of Rome

ARCADIUS became emperor (395) in the East, with a German minister, Rufinus, to direct his counsels ; Honorius became emperor in the West under the guardianship of the Vandal soldier Stilicho. The barbarians on every frontier had been held up, and the Goths had been not only conciliated but imbued with a sort of superstitious awe of the empire; they had also been converted to nominal Christianity by an Arian missionary, Ulfilas.

STILICHO saved the West from the Goths. He was the guardian of the son of Theodosius.

Nevertheless, Britain was harassed by the Caledonian tribes and by seafaring German peoples ; Maximus had withdrawn the legions from the island province, and they were never fully replaced. On the lower and upper Rhine, Vandals, Sueves, and Burgundians, Herulians, and Rugians, were pressing west and south behind the Franks and Alemanni. Immediately after the death of Theodosius, Alaric, king of the West Goths (Visigoths), dissatisfied with his position, renewed the attack on the Balkan peninsula. Rufinus was defeated and slain (395).

The menace in the East was stayed by Stilicho, the captain-general of the West. Having tranquillised the North and quelled disturbances in Africa, he transported his army to Greece and out-generalled Alaric, who came to terms and was nominated imperial governor of Illyria. Stilicho, having saved the Eastern Empire, returned to Italy, but Alaric had only changed his objective. To attack the Western Empire was to his Gothic mind no breach of faith with the Eastern. He was a great warrior, but again the Vandal Stilicho beat him in battle, at Pollentia and Verona (403). Then a confederation of German tribes burst through the Alps under their war-lord Radagaisus ; Stilicho shattered and dispersed them, and Radagaisus was killed.

Meanwhile the British provincials set up an emperor of their own called Constantine, who withdrew most of the remaining troops from Britain to extend his empire over Gaul in 407. Honorius, alarmed by the power and prestige of Stilicho, chose that moment to deprive himself and the Empire of their great defender ; in 408 Stilicho was charged with treason, and was executed.

Capture of Rome

Nemesis came swiftly upon Honorius. He had been forced to flee to the almost impregnable fortress of Ravenna, now the imperial capital of the West, while Alaric swept down with his Goths to the gates of Rome itself. For the moment he was content to extort a heavy ransom. Two years later (410) he returned and captured the Eternal City, a thing which no foreign foe had done since about 390 B.C. It is often said that Alaric sacked Rome ; but the pillage cannot have been great, or Gaiseric and the Vandals could not have sacked the city in 455.

Italy lay at Alaric's mercy, but he did not set up a Gothic empire in place of the Roman.

Apparently he meant to conquer the province called Africe without deposing Honorius, but before the year was out he died. He was buried in the bed of the river Busento, which was temporarily diverted for the purpose. The reverence with which the Empire was regarded by the barbarians in general and the Goths in particular was demonstrated when in 412 his successor, Athaulf, decided to evacuate Italy and march into Gaul and Spain. Athaulf married Galla Placidia, the emperor's sister, and became something between an ally and an officer of Honorius. In this way the Western Empire dwindled to Italy, and even there the emperor of the West now ruled only in name.

GALLA PLACIDIA. Daughter of Theodosius I, carried off by Alaric and married to King Athaulf, by her second marriage to Constantius she became Valentinian III's mother.

Barbarians Quit Italy

After the death of Radagaisus, the composite barbarian forces poured back into Gaul and broke up into their tribal hordes. The Burgundians stopped on the upper Rhine and Rhône ; the Vandals and Sueves swept through southern Gaul into Spain. Constantine set up a Gallic empire, but was overthrown and slain by Constantius the general of Honorius. The former western provinces presented a scene of wild confusion. Athaulf first assisted and then crushed two further usurpers of provincial power ; in 414 he led his Visigoths into Spain, and there was assassinated. His Visigothic kingdom included Provence, Aquitaine, and Catalonia.

Britain and Armorica (N.W. France between the Seine and the Loire) were released by Honorius from their nominal loyalty to the Empire, and told to defend themselves against their various barbarian attackers ; this they did. It took the Angles and Saxons a century to reach the Severn and the Dee and so to cut the Celtic kingdoms of Britain into separate groups. Armorica, which was once rejoined to the Empire before being completely lost, long resisted the Franks, and after them the Normans ; it remains, in smaller shape, as Brittany, a country still as distinct from France as Wales is from England.

Honorius was succeeded by Valentinian, son of his sister, Galla Placidia, by a second marriage ; Galla Placidia acted as regent till Valentinian came of age. The leading man in the Western Empire was the soldier Aetius, who bore the title of Patrician.

The Vandals in Africa

Arcadius, emperor in the East, died in 408 and was succeeded by his infant son Theodosius II. For many years the East enjoyed comparative peace, unaffected by the turmoil of barbarian movements in the West. In 428 Gaiseric, king of the Vandals, who had been pushed into Vandalusia, now Andalusia, by the Goths, transported the whole Vandal host to Africa, made himself master of that province, and established a pirate principality extending as far as Carthage. He was restrained in 441 from attacking Sicily—where no effective resistance could have been offered—by the intervention of Theodosius II. Theodosius recognized Gaiseric as sovereign of Africa and of the Mediterranean waters. Aetius had been prevented from effective action against the Vandals by an even more deadly peril.

The " Scourge of God "

This peril took the shape of the Mongolian tribes called Huns, who swept into Europe in the latter half of the 4th century. Their earliest attacks were on the barbarians beyond the imperial frontiers (*see* Lesson 22) ; the Romans

VANDAL RULER OF ROMAN AFRICA. A mosaic found at Carthage shows a horseman quitting his villa for the hunt. His features and dress are different from those in the earlier African mosaics, and it is not unreasonable to regard him as one of the Vandal invaders.

of both East and West regarded them as rather a useful check on the power of barbarian kings. Detachments of Huns were used by Roman generals in Gaul. About 440, however, the Hunnish khan or king, Attila, established authority over the whole horde and developed ambitions of world conquest. For the next 12 years he was the terror of the whole western world. He led his forces over the Danube, swept the Balkan peninsula with fire and sword, and in 443 exacted from Theodosius a huge annual tribute. He repeated the devastating invasion four years later. Attila adopted among his titles that of " the scourge of God," which is said to have been suggested to him by a hermit in Gaul.

When in 441 Attila invaded Gaul, Aetius the Patrician and Theodoric the Goth inflicted on him a tremendous defeat near Chalons. But Attila was not crushed ; the next year he was in Italy making demands on Valentinian. Aetius without the Goths could not again stake all on a pitched battle. Attila marched on Rome but retired—overawed, as men believed, by the courage of Pope Leo I, who faced him boldly and threatened him with the wrath of God if he dared advance. A year later Attila died or was assassinated. The German subjects of the Huns rose against them and smote them in battle by the river Netad in Hungary. The Hunnish empire fell to pieces, and the Huns were heard of no more (the Magyars who made the later Hungary were a different people).

In 454 Aetius met the fate of Stilicho ; Valentinian stabbed him with his own hand, and was himself assassinated some months later. Then for 20 years emperor succeeded emperor in the West, each one raised to the throne by, or by the consent of, Ricimer, who led the army but contented himself with the title of Patrician. Gaiseric the Vandal came over from Africa at the request of Valentinian's widow, but took her prisoner, sacked Rome, and sailed away again. Ricimer died in 472. Between 472 and 475, Olybrius, Ricimer's last puppet, was succeeded by Glycerius, Glycerius was deposed by Julius Nepos, and Julius by Orestes, the latest " master of the soldiers," who proclaimed as emperor his own small son, Romulus Augustus, known derisively as Romulus Augustulus (i.e. little Augustus).

End of the Western Empire

Odoacer, the captain of the miscellaneous German barbarian troops then in Italy, brought some order out of chaos by assuming personal authority in an emergency where no legal authority existed. He deposed the child Romulus without harming him, refused to acknowledge any separate Augustus of the Western Empire—whether himself or another—and caused the powerless Roman Senate officially to declare the loyalty of the West to the Augustus of the East, Zeno, at Constantinople, and to invite him to appoint Odoacer Patrician and viceroy of the West. Thus, two generations after Theodosius, in 476, the last of the Western emperors disappeared, and ancient history may be said to come to an end.

Before this Course embarks on medieval history it will be necessary to devote two Lessons to ancient history in the Far East.

LESSON 24

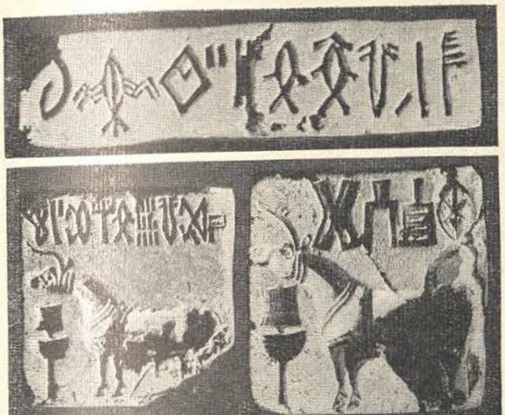
Ancient India and the Rise of Buddhism

THE world known to the ancient peoples around the Mediterranean Sea and the Persian Gulf shaded off into vagueness in almost every direction, but from time to time these peoples became aware of other civilizations eastward of their own. Seals found on the site of the Sumerian city of Kish prove what was no doubt a trading connexion between Sumer and the first known Indian civilization, which at the time of Shargani (Sargon) of Akkad (between 2700 and 2500 B.C.) occupied the great plain of the Punjab and Sind, watered by the Indus and its tributaries, and to-day mostly within the frontiers of Pakistan.

The numbers of almost vanished sites of cities in S.E. Persia, Baluchistan, Pakistan, and the adjoining Thar desert in India, suggest that considerable climatic changes helped to lay waste wide areas once well populated. Archaeologists have excavated some of these sites : the two most famous are Mohenjo-daro (" the mound of the dead ") in Sind, a few miles below the Lloyd Barrage at Sukkur on the Indus itself, and Harappa on the Ravi, 400 miles north.

Mohenjo-daro was a city three miles in circumference, built of kiln-baked brick, with an elaborate drainage system under its broad right-angled streets ; it was rebuilt at least six times, and apparently was never quite abandoned, during a thousand years. The unknown people who lived there had on their seals engraved lettering, so far undeciphered ; they grew crops round the city, had wheeled carts, various metals and textiles, wheel-made pottery, and from about 3000 to about 2000 B.C. were apparently at least as far advanced in civilization as their contemporaries in the Tigris and Euphrates delta.

Until the unearthing of this Indus valley culture it was supposed that the history of India



EARLY INDIAN CIVILIZATION. The fine example of pictorial script (upper), which has not been deciphered so far, and the bull seals (lower) came from Harappa on the Ravi, a tributary of the Indus, and are at least 4,000 years old.

began when invaders from the north-west—first of a grim procession to use the Khyber Pass—came down and brought their civilization with them into a sub-continent of primitive peoples. It now appears that the invaders—they called themselves Arya, or nobles (the name which gave to history the adjective " Aryan ")—were more likely a pastoral people, of the numerous family now described as Indo-European ; they spoke the language afterwards called Sanskrit, and they destroyed the higher civilization of the Indus valley.

Their war-god was Indra, and their great collection of hymns, the *Rigveda* (which name has been translated " science of praise " and " sacred knowledge of the verses "), apparently dated from between 2000 and 1750 B.C., when the Arya were settling the entire north of the sub-continent which takes its name from Indra. In the east they reached the plain of the Ganges, which became their principal home and is still called in their language *Hindustan*. They conquered or pushed southwards the dark-skinned ancestors of the Dravidians or Tamils who now form the bulk of the population of southern India ; and out of a long period of warfare and assimilation were developed the religious, social, and economic elements of Hinduism.

The chief feature of all these elements was the caste system (*caste* is a Portuguese word for purity of race). Pride of conquest and of colour, the professional exclusiveness of priest and soldier, the clash of belief and custom, and the problems of intermarriage, combined to produce this elaborate protective mechanism, admitting of no transference from caste to caste, and perpetuating a strict horizontal grading of society.

There were at first four main castes : the Brahmans, or priests, who alone could read the sacred books and perform the rites of magic and sacrifice ; the Rajputs or warriors ; the Vaisyas or middle-class landowners, husbandmen, and tradesmen ; and the Sudras or labourers. Outside the castes were the Pariahs—originally, no doubt, the non-Aryan parts of the population. At the beginning of the 20th century A.D. there were said to be 3,000 castes in India.

Legend and Early Literature

The obscure wars of the Hindu princes against the older peoples and between themselves are reflected in two great epics, the *Mahabharata* and the *Ramayana* (which might be called the *Iliad* and the *Odyssey* of Hindustan). The *Mahabharata* (" Great Bharata ") is a mass of legend, poetry, and moral instruction, containing elements supposed to range in date from 400 B.C. to A.D. 400 ; the events described relate to the second millennium B.C. The *Ramayana*, or story of the adventures of the prince Rama, may have been mostly composed before 500 B.C. ; it concerns a golden age of heroes round about 1000 B.C. Other religious and philosophical books expound the complicated Brahman beliefs and tell the stories of the host of Hindu gods. Many different schools of sacred learning, and a variety of sects, upheld the doctrines of Hindu religion, which ranged from the loftiest contemplation and the sternest asceticism to sensual mysticism and sacrificial magic.

The Life of Buddha

About 543 B.C. arose a great religious reformer, Gautama, who took the name of The Buddha or Enlightened One. Gautama was the son of an Indian prince ; he gave up rank and

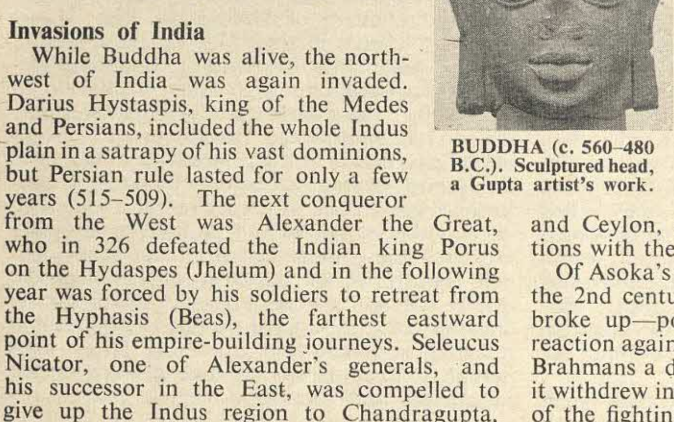
THE LOTUS IN INDIAN SYMBOLISM. In the religious symbolism of India the lotus and water-lily—figures of the sun, of purity, and of the sacred lake Manasarova, the Lotus of the World—were conspicuous. This fresco is from a Buddhist cave temple at Ajanta.

wealth and power to devote his life to service of his fellow men. He believed that a man's spiritual advancement towards Nirvana (or union with the Absolute) was conditioned by his actions ; he tried and rejected asceticism, preached and practised unselfishness, non-violence, and kindness to all living things, and avoided all ritual of worship or witchcraft or propitiation. Buddha called himself a reformer, not a founder ; he made no claim to divinity and quoted no god. He died at the age of 80, near the sacred city of Benares. His message and example appealed to the patience of the Asiatic spirit ; Buddhist monasteries were founded and became centres of learning, at first existing side by side with the temples of the Hindu gods.

BUDDHA (c. 560–480 B.C.). Sculptured head, a Gupta artist's work.

Invasions of India

While Buddha was alive, the north-west of India was again invaded. Darius Hystaspis, king of the Medes and Persians, included the whole Indus plain in a satrapy of his vast dominions, but Persian rule lasted for only a few years (515–509). The next conqueror from the West was Alexander the Great, who in 326 defeated the Indian king Porus on the Hydaspes (Jhelum) and in the following year was forced by his soldiers to retreat from the Hyphasis (Beas), the farthest eastward point of his empire-building journeys. Seleucus Nicator, one of Alexander's generals, and his successor in the East, was compelled to give up the Indus region to Chandragupta, founder of the Maurya empire, which lasted from about 321 to 184 B.C. Chandragupta was of low caste : he spread his realm across the north of India, and encouraged the Buddhists, seeing in them allies against the growth of priestcraft and caste rigidity.



BIRTHPLACE OF BUDDHIST FAITH. Siddharta Gautama received enlightenment under a fig-tree in the forest of Gaya, Bihar ; he thus became the Buddha—the Wise or Enlightened One. The reputed spot is shown here ; on the left is the famous shrine, the Budd-gaya ; on the right is a fig-tree—perhaps a descendant of that which shaded Buddha and was thenceforth called the Bo tree, or sacred tree of wisdom.

Asoka

Chandragupta's grandson Asoka was to become one of the greatest rulers of history. This king, who reigned from 264 to 227 B.C., has been called the Constantine of Buddhism. Asoka's one campaign disgusted him with war ; he announced, in inscriptions some of which still exist, that he abandoned conquest except by religious persuasion. He joined the Buddhist community, and seems to have ruled from Madras to Afghanistan in peace and with great skill and energy. But for him Buddhism might never have become a world religion ; he certainly enabled it to spread far beyond the present frontiers of India and Pakistan. His reign was a time of prosperity for a vast subject population ; his missionaries travelled to Burma and Ceylon, and he maintained friendly relations with the Seleucidae and Ptolemys.

Of Asoka's successors little is known. During the 2nd century B.C. the great Maurya empire broke up—possibly because of a Brahmanist reaction against Buddhism, which seemed to the Brahmans a danger to the Hindu state, because it withdrew into a life of contemplation too many of the fighting caste, and also because it converted and received foreigners of all kinds.

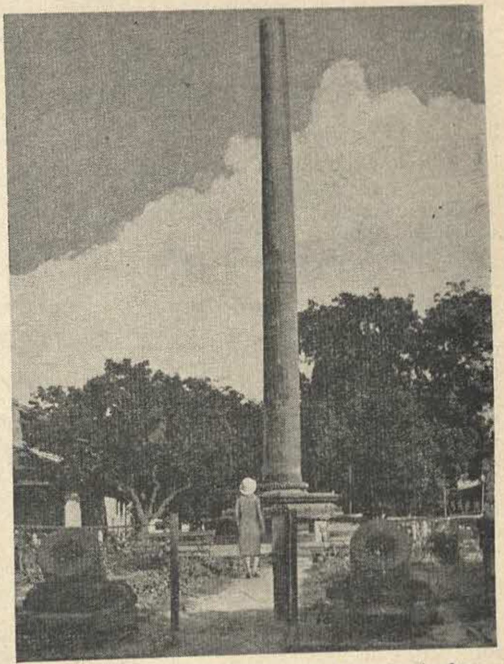
Less powerful dynasties succeeded to the chief place in northern India, their rule threatened and complicated by new invasions. Saka (Scythians), Pahlava (Parthians), Yavana (Ionians, i.e. Bactrian Greeks, the descendants of Alexander's colonists in what is now Afghanistan), were driven south by one of the recurrent surges of nomads moving for reasons still unknown out of Central Asia. This time the nomads were probably Turkish rather than Mongol ; they were called the Yue-Chi or Kushans, and they followed their defeated enemies into India and conquered the North. About A.D. 40 Kanishka, the greatest of the Kushan rulers, became a Buddhist, and seems to have set about a Buddhist revival complicated by a curious admixture of other religions. The Kushan empire in turn disappeared, and on its ashes arose, early in the 4th century A.D.—when Constantine was building his new Rome on the Bosporus—the Gupta empire, founded by another Chandragupta (*c.* A.D. 320). His reign and the reigns of his successors, Samudragupta and another Chandragupta, covered about a century; it was an age of restoration and conquest—the classic age of Hindu literature, art, and science.

Great Gupta Dynasty

Samudragupta (*c.* A.D. 326–375), after a brilliant campaign, forced the Indian rulers of the extreme south to pay him tribute. A riderless steed, in accordance with ancient Vedic ritual, was let loose to show his armies the way to victory; afterwards it became the victim of a sacrifice which concluded the successful campaign. Though a strict Hindu, Samudragupta never persecuted other religious sects. The Buddhists received their full share of state patronage; Buddha was revered as one of the greatest of early religious teachers. Buddhist monasteries became in effect universities, and the Buddhist doctrines made what proved to be a permanent impression on Hindu civilization.

After Samudragupta his dynasty lasted another 50 years. Evidence of its power and prosperity remains in monumental art and architecture, influenced by Hellenistic culture, and in the notebooks of the Chinese traveller Fa-hien, who went all over India in the days of Chandragupta II.

About A.D. 470 the Gupta power was dominated, although not entirely overthrown, by yet another horde of Central Asian invaders, the White Huns, or Ephthalites; their relationship to the Huns of Attila has not been established. They broke the Persian power and the Kushan kingdom of Kabul, conquered Sind, and established their lawless rule as far south as the Narbada river. In about 528 the Indian princes rebelled and defeated the invaders. India then became a medley of states engaged in almost continuous warfare among themselves until the first attack of the next western invaders. This time they were Moslems, who conquered Sind in 711, held it until 750, and then were driven out. When next they came it was to stay: Buddhism was fated to find its homes not in India, but elsewhere in Asia.



DISCIPLE OF BUDDHA. The Emperor Asoka organized Buddhism as the state religion and published inscriptions of Buddha's teachings on rocks or on such pillars as this example at Allahabad.

EDICT OF ASOKA. On the left is part of a rock edict found by Prof. Rhys Davids at Girnar, India.

SYMBOL OF A GUPTA VICTORY. This medal of the Hindu Samudragupta (c. A.D. 326–375) shows the white steed which led his armies to victory in southern India.

LESSON 25

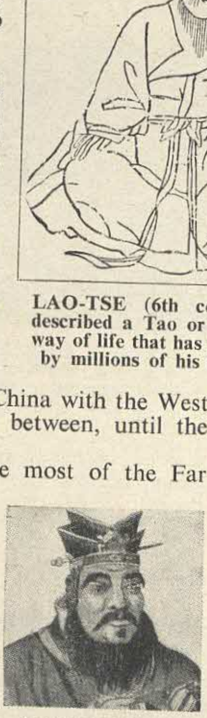
Early History of China and Japan

The historical generalisation that states follow the law of organic life—are born, have their period of adolescence, of fully developed vigour, and of inevitable decay ending in death—is impossible to reconcile with the story of China. It has a continuous history with beginnings so remote that they cannot be assigned even to a given millennium.

LAO-TSE (6th century B.C.) described a Tao or philosophical way of life that has been followed by millions of his countrymen.

In the 6th century B.C., when Darius the Great was organizing the Persian empire which Cyrus had created, the Chinese sage Confucius (*c.* 551–478 B.C.) was compiling from existing records part of the history of his nation in the *Book of Spring and Autumn*; those records date from long before his use of them. During the four thousand years of her chronicled existence the contacts of China with the West were few, and usually far between, until the 19th century A.D.

The Chinese people, like most of the Far Eastern Asiatics, are Mongolians, akin to, but not identical with, the Mongols proper or Huns of central Asia. In very early times they developed an advanced civilization in a highly organized state, of which the most dangerous enemies were those same Mongols or Huns. The legendary beginning of the Chinese state is associated with the name of the Emperor Fu-hi, to whom are allotted such dates as 2953–2838 or 2852–2738 B.C. He is said to have taught his people how to hunt, fish, herd cattle, and draw hieroglyphics. Later legendary figures dated about 2700 B.C. were the "Yellow Emperor" Huang-ti and his wife Lei-tsu, to whom are attributed the first cultivation of silk-worms and the invention of the loom.



CONFUCIUS (551–478 B.C.) taught an elaborate code of behaviour.

The Emperors Yao and Shun are also placed before the time of the first dim dynasty, the Hsia. Emperors Yu and Tang are sometimes said to belong to it, or Tang is moved into the succeeding Shang dynasty, which began to rule about 1800. The first surviving Chinese inscriptions appear on Shang bronzes. The Shang dynasty was continued in the Yin, which gave way in the 12th century B.C. to the Chou dynasty, founded by the son of a viceroy of the last Yin emperor.

The viceroy Wen Wang and his son Wu Wang, known as the "wise king" and the "warrior king," may have been of foreign extraction, for they organized the Chou empire on un-Chinese lines akin to the feudal system of medieval Europe. Barons owed doubtful allegiance to the emperor; the chief of them ruled the border provinces, being charged with defence of the marches against the barbarians. In the 10th century B.C. an innovating emperor, Mu Wang, shocked Chinese conservatism by substituting a scale of fines for the vindictive penalties assigned by custom to offences against the law.

The Chou dynasty had ruled for some 600 years when Confucius was born. The empire had long consisted of virtually independent principalities. Philosophy and learning were already held in very high esteem. An older contemporary of Confucius was the philosopher Lao-tse (meaning literally "the old philosopher"), whose *Tao-teh-King* is one of the great ethical treatises of the world. It extols humility, gentleness, and economy. *Tao* means the path or way, and Lao-tse's "great way" provided the name for the Chinese religion of Taoism. Lao-tse's treatise was not, however, religious; the passive union with the powers of nature which he expounded was later distorted to magical concepts which ignored his ethical teachings.

Unlike Lao-tse, who set no value on academic instruction, Confucius devoted himself primarily to learning and was zealous to turn it to practical account. As a teacher of morals and a political reformer he was highly efficient, in the established Chinese tradition of an adviser of princes and rulers. "Do not do to others what you would not have them do to you" was his golden rule of conduct. He laid great stress on the individual's duty to cultivate his best qualities. Knowledge is the key to virtue; there is at the heart of things a fixed order or rhythm.

MENCIUS (c. 372–289 B.C.), great disciple of Confucius.

Confucius died when about 73, in the belief that his life had been a failure; but after his death his countrymen revered him as a divinity. In spite of his originality as a reformer, Confucius was fundamentally conservative in his reverence for tradition and the past glories of his nation. He attributed the evils of his own time to the degeneration of morals since the days of Wen Wang and Wu Wang. But neither he nor his famous disciple, the philosopher Meng-tse (Mencius)—who devoted his life to Confucian propaganda—succeeded in bringing about any real reconstruction. The Chou dynasty degenerated, and in the 3rd century was displaced by the feudal rulers of the state of T'sin.

The Burning of the Books

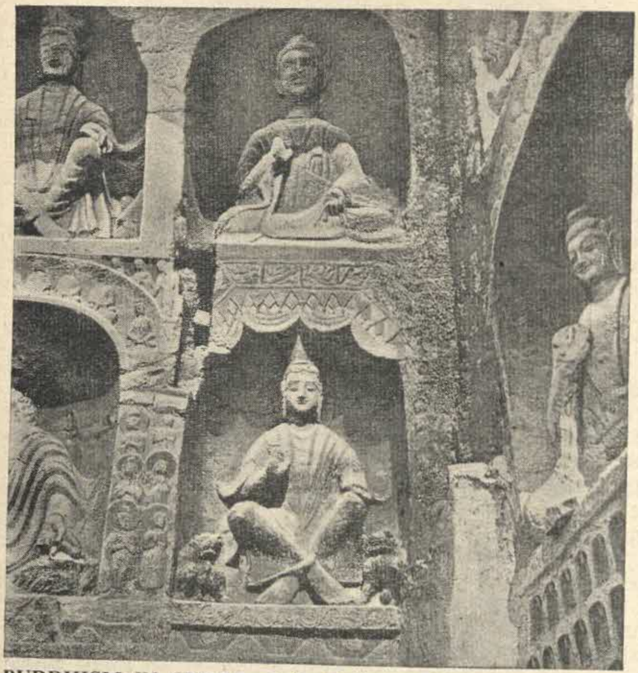
For a time there was no official emperor, but in 221 B.C. Shi Hwang Ti seized the imperial crown. It was he who built the Great Wall of China—1,500 miles of fortification against the incursions of the Huns. In one gigantic act of censorship he ordered the "Burning of the Books," the obliteration of the literature of the country, because governors and civil servants invoked the Classics in their resistance to any sort of reform, and so convinced him that advanced education of the privileged classes was a political error. Though the punishment for refusal to surrender books was death—which some hundreds of recalcitrants suffered—the destruction was fortunately not complete; the next generation did its best to make good the loss, partly from memory, partly from materials which had been successfully hidden.

Golden Age of the Hans

Shi Hwang Ti was the first despotic emperor of all China. He founded no dynasty, and a few years after his death the Han dynasty was established by Kao Tsu, and confirmed by Wen Ti (178 B.C.). These emperors reversed the anticlerical policy of Shi Hwang Ti, but otherwise made him their model. The two centuries of the Han rulers were China's golden age of strong and peaceful government; the land enjoyed prosperity, art and literature flourished, there was some extension of the northern borders, and Korea was conquered. Its glory ended with the usurpation of Wang Wung at the beginning of the 1st century A.D. He was very soon overthrown, and the line of the Hans was restored as the eastern Han dynasty, under which Buddhism was admitted into China. Trade was carried on through Parthia, and Roman merchants reached China by sea in A.D. 166.

About A.D. 220 the empire broke up into three kingdoms, not to be reunited as a single whole

THE GREAT WALL OF CHINA. Stretching for over 1,500 miles from the Yellow Sea to the borders of Kansu and Chinese Turkestan, the Wall dates from the 3rd century B.C. and was designed as a defence against the nomad Huns to the west. For 15 years the labour-power of the empire was mobilised for the task. Towards its western end the wall has crumbled into ruin, but elsewhere it is in good repair.



BUDDHISM IN CHINA. Indian influence is apparent in the Buddhas and other figures of the Mahayanist pantheon carved under the Toba Tatars in the grottoes of Yun-kang from A.D. 400 onwards.

till the 6th century, although in the course of interminable Mongol wars the northern kingdom enlarged its dominion to include a considerable part of central Asia.

The earliest external references to Japan occur in the days of the eastern Han. The point of contact was Korea. In the 1st century A.D. the "Little People" of the islands, the Wa, were in communication with the Koreans. The Chinese annalists describe them picturesquely, but these stray references do little more than confirm the Japanese tradition of an organized kingdom or empire, which had already existed for an indefinite number of centuries.

At the end of the 5th century A.D. Japanese history begins to acquire some degree of exactitude. Little reliance can be placed on the records of the Japanese themselves, since their compilation cannot be attributed to a date before the 8th century A.D. They claim that the empire dates from the first Emperor Jimmu, 660 B.C.

The most prominent figure in the Japanese tradition is that of the Empress Jingo, who is said to have conquered Korea about the 4th century A.D. There was certainly much intercourse between Korea and Japan ; Chinese books and Confucian teachers seem to have brought the art of writing into Japan by way of Korea.

The full impact of Chinese civilization reached Japan in A.D. 552 with the introduction of Buddhism.

EARLY CHINESE EMPERORS OF LEGEND AND HISTORY. This bas-relief of the Han period (c. 100 B.C.) shows the youthful Ch'eng, third sovereign, under whose guardians the kingdom was consolidated. At upper right are three legendary emperors of the pre-dynastic period, of whom Huang-ti (left) is said to have been the first (together with his wife Lei-tsu) to cultivate silkworms and to have invented spinning ; Shon Nung (centre), with his plough, was the first husbandman ; Chu Yung (right), was the first warrior. The length of reign allotted to each suggests that they represent separate families of rulers.

LESSON 1

The Stormy Dawn of Medieval History

An accepted date, arbitrary but convenient, for the division between ancient and medieval history is A.D. 476. Conditions at that time were, briefly, as follows. The Roman Empire covered the civilized world of which the West had any knowledge, a world professedly Christian, though the conflict between Catholic and Arian Christianity was still fierce. The Empire comprised all Europe west of the Rhine or south of the Danube ; all Asia west or south of the Euphrates and the Persian Gulf ; in Africa, Egypt and the whole Mediterranean littoral. Arabia was ignored at one end, Britain had been cut adrift at the other. Authority was claimed, but could not be exercised, over the barbarians beyond these bounds—Teutonic on the Rhine and upper Danube, Slavonic or Mongolian on the lower Danube. Beyond the Euphrates lay the Neo-Persian empire which had succeeded the Parthian.

SIXTH-CENTURY COSTUME. These mosaics from the church of San Apollinare Nuovo, Ravenna, show two martyred saints in court dress of the age of Theodoric.

Within the Empire, the Visigoths had left Italy to occupy Spain and south-western France under their own kings. Vandals, too, had settled in Spain, but had later transferred themselves to Africa, where they set up a pirate or brigand state. The Roman legions in Italy were no longer Roman but barbarian warriors, captained by Sueves, Vandals, Scythians, and finally by Odoacer, chief of the tribe of the Heruli. The Ostrogoths on the Danube threatened to dominate the Eastern Empire. Chaos in Italy gave to Odoacer the opportunity to remove the child-emperor Romulus Augustulus, who ruled (475–76) in Italy, and to invite the Eastern emperor Zeno to appoint him official Regent in the West.

Odoacer ruled well, and seemed to be on the way to establish a Teutonic kingdom of Italy, when Zeno took alarm and tried to eliminate two menaces at once by persuading Theodoric, the young king of the Ostrogoths, that Italy held more promise for him and his people than the Balkan peninsula. With the emperor's sanction Theodoric led the Ostrogothic people into Italy, overthrew Odoacer (493), killed him, and in fact—though always as the agent of Zeno—set up a Gothic kingdom there. Theodoric ruled from 493 to 526, with wisdom, justice, and moderation (despite some cruelties in his last years).

Theodoric's Rule in Italy

Ravenna, rather than Rome, had been the capital of Italy, and fine building had been carried on there. The mausoleum which Theodoric erected during his reign still exists. He also built three churches for Arian worship, which, with others built by his successors, are still famous for their mosaics.

Theodoric was a statesman, a diplomatist, and a soldier, whose work might have created a new western empire had a similar ruler followed him. But when he died the Ostrogoths broke up into factions. Justinian (483–565), Emperor of the East, in the vain hope of reuniting the Roman Empire, sent armies to Italy under two great commanders: first Belisarius, who had already exterminated the Vandal kingdom, and then Narses who, after long and hard campaigning, almost annihilated the Ostrogothic forces and drove the remnant out of Italy. The Ostrogoths disappeared completely ; an imperial viceroy called the Exarch was established at Ravenna, but was never accorded the support necessary for efficient government.

Meanwhile, another Teutonic or Germanic domination, more barbaric than that of Visigoth or Ostrogoth, was being extended from the

Rhine over all the country now called France. The Salian or coastal division of the Franks first settled by the mouths of the Rhine and the Meuse ; the Riparian or river-bank division settled in the flat land of Champagne and Lorraine and on the left bank of the middle Rhine. The Scandinavian branch of the Teutons (Goths, Vandals, and others) had adopted the Arian form of Christianity, which rejected the orthodox doctrine of the Holy Trinity; the German Franks remained heathens until, in 496, their king Chlodwig (or Clovis) embraced the faith of his Christian Burgundian wife, Clotilde. At his bidding the majority of his subjects followed his example ; and they became not Arian but Trinitarian converts.

Clovis, King of the Franks

Orthodoxy secured for Clovis the good-will of the Catholic clergy, and through them of the subject Romanised population through the whole of western Europe, and was doubtless one cause of the rapid extension of the Frankish kingdom. In 507, as the champion of orthodoxy against Arianism, he challenged the Visigothic king to battle, and defeated and slew him on the plain of Poitiers. The Visigothic monarchy survived for some time south of the Pyrenees, but within Gaul it retained only a corner of territory on the west of the Gulf of the Lion, at that period called Septimania. In 587 the Arian heresy was overthrown in Spain.

Clovis died in 511 ; his sons and descendants, the Merving or Merovingian kings of the Franks (named after Meroveus, grandfather of Clovis), continued his profitable policy of religious warfare, and finally added the fruitful province of Burgundy to the Frankish kingdom, which thus came to include the whole of modern France—save for the little strip of Septimanian territory—and also the Netherlands, the Rhineland, and an indefinable extent of country beyond the Rhine. In the 7th and 8th centuries it was the most powerful of the barbarian kingdoms ; but Frankish custom frequently divided it between brothers, who invariably fought each other for supremacy.

Coming of the Lombards

In 568, fifteen years after the expulsion of the Ostrogoths from Italy, the Lombards or Langobards, another Teutonic horde, under the ruthless Alboin, arrived in the peninsula. They were much more uncouth and barbarous than the Ostrogoths, and their religion was either Arian Christianity or heathenism. Pope Gregory I (*c.* 540–604), justly called the Great, complained that he lived " between the swords of the Lombards " ; the fierce enmity between the Papacy and the Lombard kings was not appeased even by the conversion of the latter to Catholic Christianity.

The conquest of Italy by the Lombards was only partial. From their capital at Pavia they ruled the greater part of the valley of the Po. Tuscany was theirs, and most of the country on the flanks of the Apennines, divided into the two duchies of Spoleto and Benevento. But the city of Naples, the toe and heel of Italy, the island of Sicily, and—in the north-east corner of the land—the all but impregnable city of Ravenna, the seat of the imperial Exarch, were still in the imperial allegiance. Rome was, of course, also nominally imperial ; but the Popes, who had many a theological battle with the Eastern emperor, were showing an increasing tendency to rule Rome and the Western Church independently of Constantinople, although the final separation of the Latin or Catholic Church from the Greek or Orthodox Church of the East had not yet arrived.

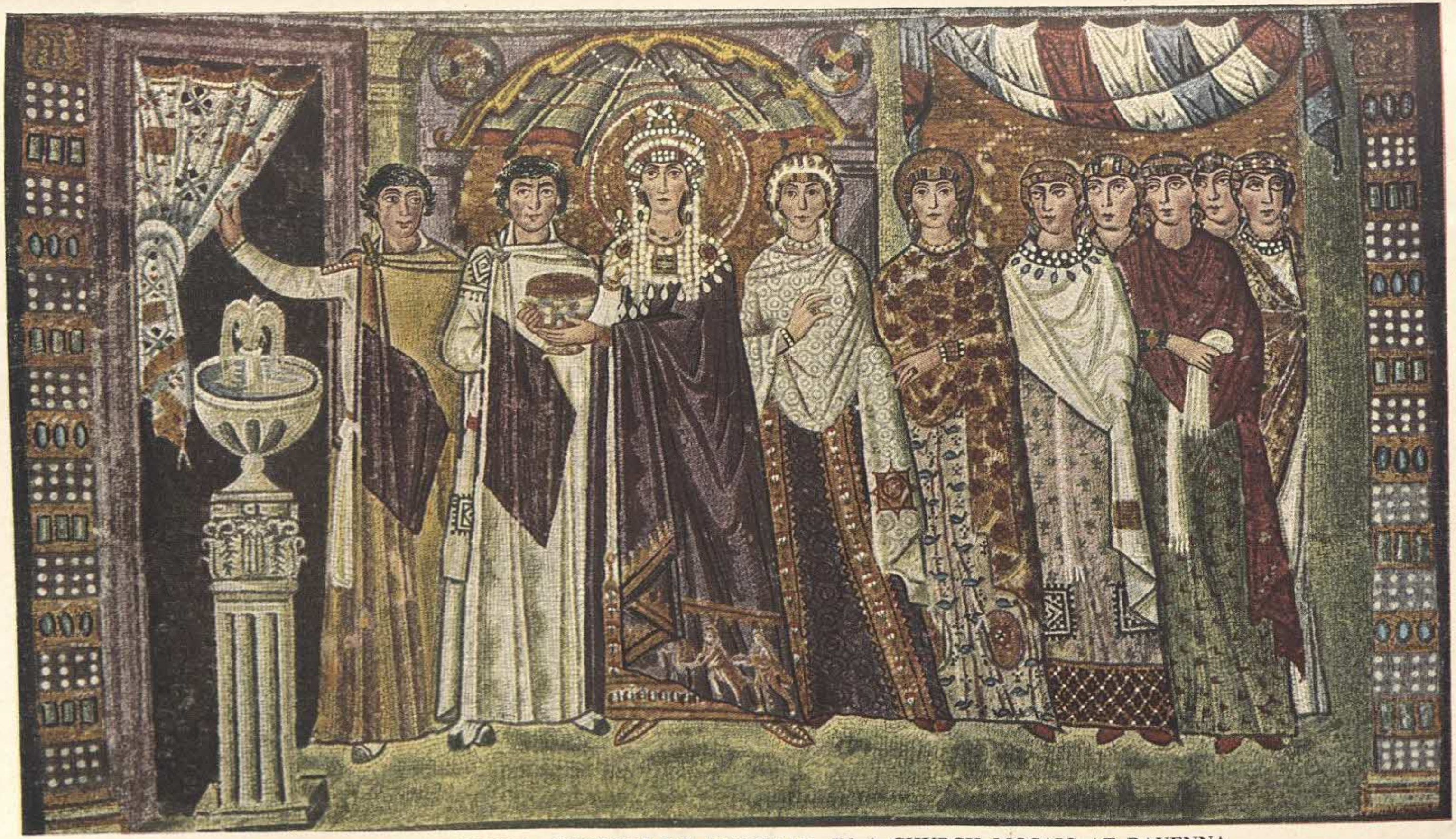
During the same period a little city amid the mudbanks of the Adriatic, which afterwards came to be known as Venice, was quietly increasing in wealth and power, holding the Lombard barbarians at bay and professing unbounded loyalty to the distant Byzantine emperor—being comfortably beyond his reach.

LESSON 2

Byzantium and the Moslem Menace

THOUGH Justinian (A.D. 483–565) attempted to reassert the imperial authority in the West by destroying the Ostrogothic power in Italy, the power recovered by Byzantium was shadowy. The reunion of East and West had ceased to be practicable. In his reign the Eastern empire was at its height, and he is commemorated in the West by mosaics in the churches at Ravenna. Here also, in the church of San Vitale, his empress Theodora is depicted in gorgeous robes with her court ladies. Formerly an actress of notorious reputation, Theodora was a woman of forceful character, whose loyalty to her husband and influence over him never waned after her marriage. While capable of courage and energy, she was also self-indulgent and extravagant.

In the age of Justinian, Constantinople was adorned with many new buildings, of which the most famous and impressive was the cathedral of St. Sophia. Many churches were erected, and palaces were enlarged ; residential quarters of Constantinople must have looked much like those in a modern city, with fine houses for



THE EMPRESS THEODORA, CONSORT OF JUSTINIAN, IN A CHURCH MOSAIC AT RAVENNA

In this 6th-century Byzantine mosaic in the church of San Vitale, Ravenna, the empress is shown about to leave her throne room to make an offering of a gold chalice. The first and second ladies on her left are believed to be Antonina and Joanna, wife and daughter of Justinian's great general, Belisarius. The mosaic is evidence of the level of Byzantine art of the period, and of the sumptuous character of the court robes worn by the empress, her ministers, and her ladies.

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the wealthy, and for the workers blocks of flats, with shops on the ground floors. An elaborate system of drainage was installed. Huge underground cisterns for water supply were constructed within the city. One of the largest of these was the famous "Palace of Waters," an underground hall, the roof supported by 420 pillars set in rows. A parallel has been drawn between Justinian and Louis XIV of France. Both were magnificent builders and patrons of the arts; both were much influenced by priests and women; both attempted impressive conquests, and ended by bringing their states close to bankruptcy.

Apart from the obliteration of the Vandal kingdom by Belisarius, his heroic general, the extensive military operations of Justinian's reign were grandiose but not of much value. Justinian's enduring fame rests upon his great work of codifying and giving permanent shape to the vast mass of laws and precedents accumulated over hundreds of years by the Roman legal system. The Code of Justinian became the basis of practically every legal system in Europe, with the one notable exception of England.

JUSTINIAN (A.D. 483-565) is pictured *in many* mosaics at Ravenna. This head is in the Basilica of San Apollinare Nuovo.

For half a century after Justinian's death the restiveness of Slavonic and Mongolian barbarians on the Danube, and Persian aggression in Asia, kept the Eastern emperors busy. Between 613 and 620 the Persians practically conquered Syria and Egypt, overran Asia Minor, captured and sacked Jerusalem, and threatened Constantinople, which was at the same time threatened from the north by the Mongolian Avars. Nevertheless, in the heroic fashion displayed at intervals by the Romans of the Eastern empire, armies continued to be raised; in a series of brilliant campaigns between 622 and 628 the Emperor Heraclius drove the Persians behind the Tigris. But a new danger was threatening.

RULER OF THE EASTERN EMPIRE. Attended by ministers, the Bishop of Ravenna, and an armed bodyguard, Justinian is seen in this Byzantine mosaic from the church of San Vitale, Ravenna, making a dedicatory offering. (*See also* **colour plate f.p. 368.**)

Arabia had never come under the influence of neighbour civilizations—Egyptian, Syrian, Greek, or Roman. The Arabians were still nomads or primitive agriculturists. Traditionally, they claimed descent from the father of the Hebrew race through Ishmael; but in the 6th century their religion was a conglomerate of fetish worship and demon worship, with borrowings from Judaism, Christianity, and other Eastern religions. In the city of Mecca a temple and a stone called the Kaaba were general objects of veneration traditionally associated with Adam and Abraham.

Rise of Mahomedanism

In these unpromising surroundings the prophet Mahomet (*c.* 570-632) became possessed by the idea that he must undertake a mission of regeneration; the archangel Gabriel appeared to him in a vision. Mahomet began to preach moral and religious doctrines at variance with anything to which the Arabs had been accustomed. He was met first with scoffings, then with persecution, and in 622 he was obliged to take flight from Mecca; this year of the Prophet's flight, which is called the Hijra, or Hegira, is reckoned as the first in the Mahomedan era, as is A.D. 1 in the Christian era.

The Spread of Islam

But the Prophet found followers; they grew in numbers. Their leader claimed, and they believed, that his pronouncements were inspired. They made war upon and were victorious over the unbelieving Meccans; the Kaaba was converted into the sacred shrine of the new faith. The Prophet and his followers set themselves to compel submission to his authority at the sword's point. When the Emperor Heraclius (*c.* 575-642) was at war with the Persian emperor Chosroes II, both of them received letters inviting them to recognize and submit to the Prophet of Allah—letters which the Persian received with contumely and

Heraclius with polite contempt. Neither imagined that an obscure Arabian was about to turn the world upside-down.

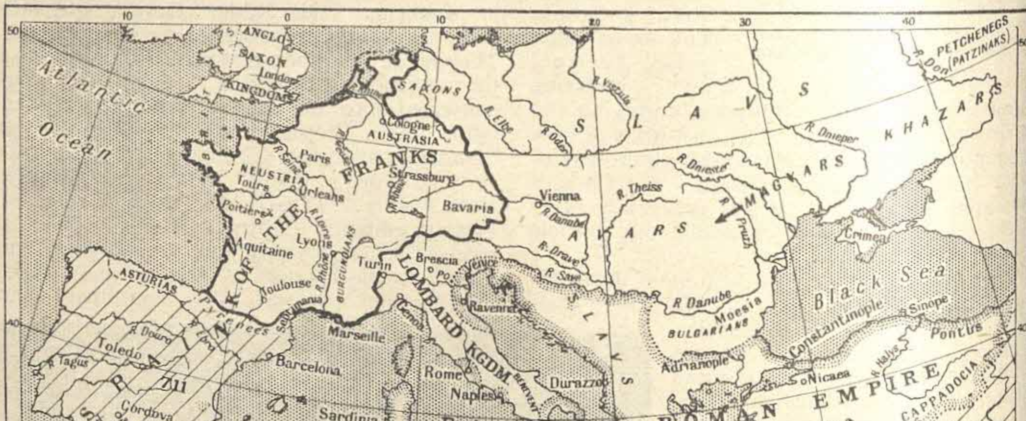
Mahomet's death was a shock to his faithful followers ; but the ablest of his disciples, Abu Bekr, was chosen as the first caliph, or successor of the Prophet. Rivals naturally sprang up and were suppressed ; the devotees of the new faith had first established it by the sword and were fanatically resolved to spread it by the same means. The Moslems, organized after Abu Bekr by the great Omar, advanced first to the East, offering to all opponents the three alternatives conversion, submission and tribute, or death ; they carried their victorious arms across the Euphrates and across the Tigris, and turned upon Syria, which was a portion of what was still called the Roman Empire. Having absorbed Syria into their dominion, they burst into Egypt, and in 641 captured Alexandria.

The progress of Islam was as rapid in Africa as it had been in Asia ; in no part of his dominions overseas could Heraclius from Constantinople offer an adequate resistance. His successors proved no better able to deal with the situation. Presently outside of Europe little remained to the empire except Asia Minor. The Saracens, as the followers of the Prophet began to be called, built fleets which dominated the Mediterranean, carried their faith westward among the Berber tribes on the African coast, flung themselves upon Sicily, and at the end of the century were on the point of invading Spain.

The Ommayad Dynasty

The caliphate, combined religious and military leadership of Islam, had fallen into the hands of a family called the Ommayads. Under them the Saracen dominion had spread over the East to the farther confines of the Persian empire. Early in the 8th century Arab invaders entered the Punjab, although they did not then establish a permanent dominion in India.

The house of Heraclius had failed to defend Africa and Asia east of the Taurus mountains against the Moslem deluge ; but Constans, grandson of Heraclius, held the Saracens in check, though he failed to recover lost territory. The vigour of their attack was weakened by dissension among the faithful and struggles for possession of the caliphate. A great number of Moslems maintained that the true succession lay with the house of Ali, the son-in-law of the Prophet, husband of his daughter Fatima ; this faction came to be called the Shiites or



THE MARCH OF CONQUERING ISLAM. The extent and rapidity of Moslem conquests are illustrated in this map. Within 16 years of the Hegira, Syria was overrun, two years later Egypt. Then began the march of conquest along the north African coast. In 711 a Saracen host crossed the Strait of Gibraltar. Soon the whole Iberian peninsula was occupied. The invaders moved northward across the Pyrenees, and were hurled back again after their defeat near Poitiers by the Franks under Charles Martel.

THE GREAT MOSQUE AT DAMASCUS. With the establishment of the Ommayad dynasty in 661 Damascus became the seat of the caliphate. In the reign of Walid (705–715) the Great Mosque was built there (in its present form).

Fatimites. Opposed to the Shiites were the more orthodox Sunnites, who accepted as their rule not only the Koran but the Sunna, i.e. collections of traditional sayings and doings of Mahomet put together in the 9th century. For a time, therefore, the attack upon the Roman Empire was relaxed.

Constans II used his opportunity to recover a partial and temporary supremacy in Italy. While he was in the West, the Saracen attack was renewed. Constans was assassinated (668), and was succeeded by his young son Constantine IV, called Pogonatus, the Bearded. This time the Saracens pierced the Taurus, overran Asia Minor, and threatened Constantinople itself. Constantine shattered their fleet, routed their land forces, and drove them back out of Asia Minor, but was unable to counter-attack beyond the Taurus. Justinian II, whose remarkable abilities were counterbalanced by ungovernable passions and a singularly cruel and capricious disposition, was killed in a military revolt; and once more there was a brief succession of emperors raised to the purple by one military faction only to be overthrown by another one. At about this time the Mongol Bulgars effected their settlement in the Danube valley. Slavonic tribes of "Aryan" stock had also long been spreading themselves over the Balkan peninsula. The Bulgars were dominant, and gave their name to what is now known as Bulgaria; but the adaptable Mongol stock mingled with, and became absorbed in, the Slavonic, so that before long the Bulgarians were not so much Mongols as Slavs.

LESSON 3

The Clash of Cross and Crescent

EARLY in the 8th century the Mahomedan attack on Christendom was renewed. Walid, who became caliph in 705, increased the power of the caliphate, chose able ministers to rule under him, and was a generous patron of the arts. In Damascus, his capital, the Great Mosque was erected (in its present form) during his reign. Disorder at Constantinople enabled his troops to overrun Asia Minor, but his main military efforts were directed to establishing power in the farther East. His successor Suleiman opened an attack upon the Christian empire. The first onslaught was checked at Amorium, in the centre of Asia Minor, by the imperial general Leo (*c.* 680–741), called the Isaurian, of a race of mountaineers of eastern Asia Minor. Leo saw that the Saracens were not to be held back by isolated efforts; there must be order at Constantinople if organized resistance was to be offered. From Amorium he hurried to Constantinople, where the reigning emperor was wise enough to abdicate. In 717 Leo was acclaimed emperor as Leo III.

Suleiman's armies poured across Asia Minor; his fleet dominated the Aegean Sea; his troops were carried over to Europe, and Constantinople was shut in upon the west as well as upon the east. But through the winter Constantinople defied attack, and Leo's ships, issuing from the Golden Horn, broke up the enemy fleet. As the spring of 718 advanced the Bulgarian king was induced to lend his aid. He attacked the Moslem force on the west, and inflicted upon it a great defeat. Leo himself had by this time dealt a heavy blow to the forces on the other side of the Dardanelles. The Saracens in Europe were hampered by failure of supplies, and the siege was raised; the remnants of the army were embarked in the fleet, and most of the fleet went to the bottom in a storm.

Islam's Defeat in the East

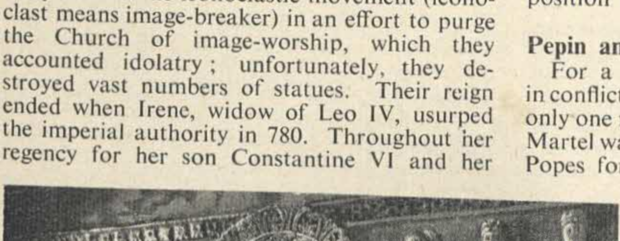
Leo's great defence of Constantinople was decisive in the East. In following years the Saracens were expelled from Asia Minor, though the empire never effectively recovered territory beyond the Taurus mountains. Leo's successors held what he had won. Rivalry between aspirants to the caliphate paralysed Islam. The Ommayad dynasty was overthrown and its place taken by the Abbasids about 750 ; the caliphate then acquired new splendour, with Baghdad instead of Damascus as its capital. Before that happened, however, the African Moslems, collectively called Moors, had planted in Spain a dominion that endured for nearly 800 years.

Moorish Invasion of Spain

The caliphate in the East had little or no control over the Moors. The Visigothic kings in Spain had no better control over their nobles. In 711 a Moorish host crossed the Strait of Gibraltar (*Jebel-Tarik*, the mount of Tarik, who was the Moslem commander), annihilated the Visigothic army on the Guadalete, and overran the peninsula. The Goths were driven into the mountains and almost exterminated. Masters of Spain, and reinforced from Africa, the Moors a few years later poured through the Pyrenees into southern France; but in 732, somewhere between Tours and Poitiers (the battle is called by either name), they were shattered by the Franks under Charles Martel (the Hammer), who drove most of what was left of them back through the Pyrenees, which they never recrossed.

EASTERN EMPERORS. Leo III ruled from 717 to 741, and defeated the Saracens. Irene (right) was regent from 780 to 797 and empress until her banishment in 802.

After his repulse of the Saracens the emperor Leo and his descendants ruled the Eastern empire with vigour and ability for some 60 years. They headed the iconoclastic movement (iconoclast means image-breaker) in an effort to purge the Church of image-worship, which they accounted idolatry ; unfortunately, they destroyed vast numbers of statues. Their reign ended when Irene, widow of Leo IV, usurped the imperial authority in 780. Throughout her regency for her son Constantine VI and her own reign (797–802) she was an ardent image-worshipper, summoning the Second Council of Nicaea in 787 to reverse the decisions of the Council of Constantinople of 754 which had forbidden image worship.



LOMBARD COSTUME. Byzantine influence is marked in the robes of these stucco figures from the Chapel of the Lombard Kings at Cividale del Friuli. Compare them with the court dress of Theodora's ladies (*see* colour plate f.p. 368).

The Franks were loyal to the line of the Merovings, though the kingdom was habitually divided between different members of the family, but that line had degenerated before the middle of the 7th century. Real government was carried on by an official with the title of mayor of the palace. This office became in effect hereditary in a warrior family from the Rhineland called the Arnulfings, of whom the most famous was Charles Martel. They extended Frankish rule over the Germans east of the Rhine, but although Charles drew the Franks together and delivered Western Christendom from the Mahomedan menace in 732 he was able to make the south secure only by hard fighting.

The puppet king died and no Merovingian heir was forthcoming ; Charles Martel refused the crown and continued to rule with the title of Duke of the Franks. In 741 he was succeeded by his two sons, Pepin the Short, and Carloman, who worked in harmony till Carloman retired into a monastery and left Pepin sole ruler in 747. The brothers found a young Merovingian prince, Childeric, in a monastery, and regularised their position by crowning him king of the Franks.

Pepin and the Papacy

For a hundred years the Papacy had been in conflict with the Lombards, who had produced only one memorable prince, Liutprand. Charles Martel was honoured and respected by successive Popes for his defence of Christendom and his zeal in Christianising barbarian German tribes ; but he had turned a deaf ear to appeals for intervention against the Lombards. In 751 Pepin was elected king by the Franks gathered in a national assembly, but Childeric was the anointed king, and Frankish consciences required religious sanction for his deposition ; Pepin asked the Pope whether the royal title should not accompany exercise of the royal authority. In answer, Pope Stephen II crossed the Alps and at St. Denis crowned and anointed Pepin in 754. Later Popes claimed this as an admission that their authority extended to the deposition and appointment of kings, and founded upon that admission the temporal power of the medieval Papacy. Pepin could now no longer resist papal appeals for intervention against the Lombards, who had already annexed Ravenna and expelled the imperial exarch. Accordingly he descended on Italy, vanquished the Lombard king and compelled him to swear allegiance, handed over Ravenna and other recent Lombard conquests to the Papacy, and withdrew over the Alps to complete his work of consolidating his Frankish kingdom. Presently he expelled the last remnant of Saracens from Septimania, and brought to submission the rebellious dukes of Aquitaine on one side and Bavaria on the other. The kingdom he left to his sons in 768 was the largest and most powerful in Europe. It was divided between Charles and Carloman ; but after three years of quarrelling the death of Carloman in 771 left his brother Charles (Charlemagne) undisputed king of the Franks.

LESSON 4

Charlemagne and the Holy Roman Empire

CHARLES THE GREAT, Carolus Magnus (742–814), universally known through legend and literature as Charlemagne, most famous of the Carolingians, had been king of the Franks for 30 years before the grateful and astute Pope Leo III was (by his own account) inspired to crown him emperor of the Holy Roman Empire, at Rome, on Christmas Day in the year 800. The king and emperor Charles is the most striking figure, as the birth of the Holy Roman Empire is the most striking event, in medieval history.

SCS PETRVS
DN LEO PP
CARVLO REGI
BEATE PETRE DONAS VITA LEONI PP E BICTORIA CARVLO REGI DONAS

SPIRITUAL AND TEMPORAL POWER. In 800 Charlemagne was crowned in St. Peter's by Pope Leo III and proclaimed emperor of the Holy Roman Empire. This mosaic shows Pope and emperor at St. Peter's feet.

During those 30 years he had been conquering, organizing, evangelising at the sword's point, educating, building up the widest dominion ever ruled in Europe by any one man except Russian tsars or by Napoleon at the zenith of his power. Out of his system was developed feudalism. The revival of a Roman empire in the West, associated with the Western Church, was an attempt to realize a Christendom united under two heads, one spiritual, one temporal, the Pope and the Emperor. The result was almost unceasing conflict between the two, because no dividing line could be drawn between spiritual and temporal functions. That Christmas morning at Rome was thus the signal not for peace and unity but for the strife of many centuries.

Charles began his career as a conqueror in 773, by taking the Lombard kingdom. His excuse was a quarrel between the Lombard king and the Pope ; most of the Lombard nobles, with the notable exception of the marquess of Spoleto in the south, took the oath of allegiance and gave little further trouble. To invade Lombardy Charles had postponed his move against Saxony, which presented a more serious task—much like that which proved too difficult for the Romans in the days of Augustus and Tiberius.

West Saxony was apparently subdued and compelled to accept Christianity in 776 ; but while Charles was campaigning in Spain the Saxons again rebelled. Charles conquered them again in 779 and baptized them by the thousand, but had to return years later, spreading fire and slaughter until their final submission in 785. This time the conquest was effective—though there were sporadic revolts later—and Saxony became a Frankish province.

The Spanish expedition against the newly established emirate (soon to be the Cordova caliphate, independent of Baghdad) of the Ommayad Abderrahman, in 778, gave rise to the famous legend concerning Charles's commander, the paladin Roland. This legend, embodied in the *Chanson de Roland*, is the foundation of the vast traditional literature about Charlemagne. The annihilation of Roland's force, at Roncesvalles in the Gascon country, made a great theme for minstrels ;

CHARLEMAGNE AS CHURCH BUILDER. Charlemagne was a great builder and German Romanesque may be said to date from his reign. This sculpture from his shrine shows him offering the new cathedral at Aachen (Aix-la-Chapelle) to the Virgin Mary.

in time it was elaborated into the epic that glorifies Roland and his companions as martyrs in a Holy War. The campaign was against the Moors in the first place, but Roland had trespassed on his northward march, and the ambush in the pass was historically the work of Gascon hillmen.

Charles's aim was not the conquest of Spain but the establishment of a strategic frontier along the Ebro, behind which the Moors were gradually driven and confined by treaty in 812. Without being brought formally into the Frank kingdom, Slavonic tribes beyond the Elbe readily acknowledged the Frankish supremacy. Charlemagne turned east again, and after much campaigning subdued the Khan of the Mongol Avars in Hungary.

Charles as Emperor

When Pope Leo III hailed Charlemagne as Roman emperor and Caesar, he was really admitting an accomplished fact. The ruler at Constantinople was Irene, and the pope, who claimed spiritual supremacy over the whole Christian Church, found no difficulty in transferring his temporal allegiance to a Catholic prince from one who upheld the heresies of the Church in the East.

As emperor, Charles embarked on no new projects of expansion. Together with the imperial crown he accepted a tremendous responsibility. It was necessary to try to complete an imperial organization based upon the Frankish system blended with persistent elements of the bygone Roman provinces. The title of emperor added nothing to the dominions of the great king of the Franks; Charlemagne's favourite capital was still Aachen, in a conveniently central position in the Frankish Rhineland, where he himself directed the building of a great city. "Here," in the words of a Latin poem of the period, "shall be the forum and the holy senate, which shall deal justice to the people and dictate the law to it." Here rose the royal palace, the famous church, the theatre, and the marble building enclosing the hot baths.

Charles's government was an autocracy and his own word was law. Franks were naturally more likely than others to be appointed to offices of state, but they had no monopoly of office, and no privileges as Franks. There were three geographical divisions of the empire, each containing a more or less defined racial entity; east of the Rhine as far as the Slavonic border were Germans almost untouched by Latin influence; west of the Rhine were thoroughly latinised Celts and slightly latinised Teutons, the former preponderating; south of the Alps were Latins with a mainly Lombard aristocracy.

Those three strongly marked divisions were never really amalgamated; their populations separated into German, French, and Italian. But the central wedge from the Rhine mouth to the Alps, where the races were most mixed, gravitated sometimes to one side, sometimes to the other; and the Rhône basin, Provence, the one-time Roman Provincia of Gaul, might have become Italian instead of French had a united Italian kingdom ever emerged to absorb it—much as Catalonia, between the Ebro and the Pyrenees, was absorbed in the later Spanish kingdom of Aragon. The name of the Frankish nation survived both in France and east of the Rhine, in Franconia.

Administrative Methods

In the empire the emperor was supreme, recognizing no antagonism between the papal functions and his own. Had they clashed, the Pope would have given way as a matter of course. Charles ruled as a faithful son of the Church, but as the undoubted head of Western Christendom, and did not challenge the Eastern Empire in its own sphere, deeply as the eastern Romans resented his assumption of the imperial title. He ruled also as king of the Franks, summoning a General Assembly of the nation twice a year to hear and approve his projects. The whole dominion was divided into governorships; governors, appointed by himself and removable at his pleasure, were responsible to him for the maintenance of law and order. They were bishops, dukes, counts or, in border provinces, margraves (counts of the marches), and frequently they were local nobles, but there were no hereditary governorships; succession of son to father was a natural later development.

Charles's appreciation of the danger of this rise of powerful and ambitious families probably led to his extensive employment of clerics. They helped to keep Church and State working together in harmony. Under a strong and self-reliant monarch of a heterogeneous empire the system was sound ; but it had in it the germs of disintegration. To carry on the work another Pepin or Charles Martel was needed ; but the Carolingians who followed fell away from the standards of their ancestry.

While Charles lived, however, he seemed to have revived in the Holy Roman Empire that Roman peace which had been the moral justification of the old empire's existence. He was indeed great as a conqueror and organizer, but his best title to be called great may derive from his grasp of the hitherto unrecognized value of education. Like his contemporary, Harun al Raschid, Caliph at Baghdad, Charlemagne needs no mythical trappings to warrant his inclusion among the greatest men of history.

LESSON 5

Emergence of the Western Kingdoms

When Charlemagne died in 814, at the age of 71, in his palace at Aachen, his only surviving son, Louis, crowned himself emperor and king of the Franks. This he did as by indisputable right, though his elder brother's son was king of Lombardy ; he himself had long been king of Aquitaine.

Clearly Charlemagne had intended that after his death there should be one supreme emperor, but that the Frank kingdom should be divided, according to the immemorial custom, among his sons, on each of whom he had bestowed a kingdom during his own lifetime ; but the two elder and more capable of his sons had died before him.

LOUIS I, THE DEBONAIR (778–840). Third son of Charlemagne, he became Roman emperor on his father's death in 814. This miniature shows him with the closed Byzantine form of crown.

Louis I, nicknamed the Pious, and also the Debonair, was an example of that type of piety represented in English history by Edward the Confessor. It hopelessly unfitted him for imperial responsibility, which twice at least he was anxious to resign in favour of retirement to a monastery. He sanctioned the death of his nephew Bernard, king of Lombardy, who came to him under safe conduct, and was haunted by this sin for the rest of his life. His sons, on whom he bestowed kingdoms, were in perpetual revolt, knowing that if they were defeated they were secure of pardon and reinstatement. In the last year of his life (840) he suppressed a revolt in which his eldest son Lothair had for once taken no active part. Consequently, when Louis died, Lothair (who was already king in the Rhineland, which took from him the name Lotharingia, later Lorraine) became emperor.

Lothair and his two brothers, Lewis (called the German), and Charles the Bald, were soon fighting again ; but they eventually came to agreement in the Treaty of Verdun (843). The emperor kept a great central kingdom from the Rhine mouth on the north to the Rhône mouth on the south, together with Italy ; Lewis was king of the Germans eastward of it, Charles II (the Bald) king of all Gaul, or France, west of it.

Lothair gave his own eldest son Lewis the kingdom of Italy. This Lewis (not his uncle, Lewis the German) became emperor in 855, but continued to be preoccupied with Italy. In 875 he died, leaving no heir. In 876 Lewis the German died, and in 877 Charles the Bald. The successor of Lewis was his son, Charles III (the Fat) ; in 884 the sons of Charles the Bald were dead, and their heir was the infant afterwards known as Charles the Simple. In loyalty to the Carolingian dynasty the West Franks, being in need of an adult king, gave their crown to Charles the Fat, who had already secured the imperial crown, the Italian crown which went with it, and Lotharingia.

Out of this confusion rose the first shape of a country that exists to-day. In 887 Charles the Fat, having proved incapable and having surrendered the German crown to his rebellious—and illegitimate—cousin Arnulf of Carinthia, died. The West Franks, refusing to acknowledge Arnulf, elected as their king the distinguished warrior Odo, count of Paris. From that time no king of France—as we may thenceforth call the western kingdom—owned allegiance to an emperor, or himself wore the imperial crown. For some time the imperial authority was in abeyance, though the title was sometimes borne by some rival prince of Carolingian descent.

While the kings were fighting to snatch territory from each other, only Lewis king of Italy paid much attention to the duties of government. Such duties were left to the dukes and counts. When one died, it saved trouble to pass the governorship on to his son, so that by the end of the 9th century their families had come to regard the succession as a hereditary right, and the disintegrating legalist theory of feudalism was generally established. All the land was the king's, yet he had distributed it among magnates who held their territories by hereditary right, under the pact of allegiance.

CAROLINGIAN COSTUME. This miniature shows Charles the Bald accepting an illuminated Bible from the canons of St. Martin at Tours in 869. The clergy wore ornate vestments, the king a Roman type of costume.

Beginnings of Feudalism

They were required to do homage to him as his "men," and to render him military and other services upon conditions equally binding on both parties, failure in which justified, on one side, renunciation of allegiance, and, on the other, forfeiture of territory. Similarly, within the dukedom or county the big landholders held their land from the duke or count. Everyone held his land as tenant or vassal of an overlord in a pyramid of allegiance with the king at the apex ; but the continental system differed from that established later in England. On the Continent, the vassal's allegiance was to his immediate overlord ; then a duke's vassals would follow him against the king, and their vassals followed them without feeling that they were committing treason.

Another most important result of the kings' preoccupation with their quarrels was that individual nobles were left to defend their territories against invaders; and all through the century the Northmen from Denmark, Norway, and, to a lesser extent, Sweden, were swarming along the coasts and thrusting up the estuaries, robbing and pillaging, but avoiding pitched battles. The nobles learnt to build impregnable strongholds and to pursue the raiders with mounted men ; castles and armoured cavalry became the prominent features of medieval warfare and the measure of the military power of every noble. Before he was raised to the French throne Odo, count of Paris, saved that city from the Northmen. Early in the next century the raiders established themselves on the French coast ; in 911 one of the chiefs of the Northmen, Rolf or Rollo, acquired the duchy of Normandy.

In the reign of Lewis of Italy the Saracen menace had revived. Saracen fleets dominated the Mediterranean. Saracens swarmed into Sicily (which, with the "boot" of Italy, was still attached to the Eastern Empire) and conquered it ; they planted pirate fortresses on the mainland, and retained Sicily and Sardinia for two centuries.

This western extension of Arabic influence is important. The Saracens brought Arabic arts and products to the ports of Christendom. For 200 years they held Malta (the Maltese language is still a corrupt Arabic dialect) ; they bequeathed the Saracenic style of architecture to their successors, the Norman kings of Sicily. In the 10th century the Saracens were the distributors of learning in Europe. Arabic medicine was studied at the medical schools of Salerno and Bologna. Arabic ideas pervaded the universities, just as the artistic craft of the Saracenic glassworkers and damasceners filled the Italian markets, where separate booths were reserved for Oriental traders.

Even in France, where the victory of Charles Martel had turned the tide of Arab conquest, the Saracens kept some influence in Provence; the mountains of Les Maures preserve the Moorish name, and lays of the troubadours have affinities with Arabic poetry. In Moorish Spain, Arab culture outshone the glory of the Baghdad caliphate. It was displayed in many important buildings, from the mosque of Cordova, begun in 786, to the Alhambra at Granada, built in the 13th and 14th centuries. The service to Europe of the vast Arabic literature was that it prepared the way for the Renaissance.

During the struggle the Eastern Empire had failed to make effective intervention on behalf of its subjects, but in 867 the adventurer Basil the Macedonian, groom and boon-companion of the drunken emperor Michael, murdered his master, seized the crown of the Caesars, and founded an imperial dynasty which reigned at Constantinople for some two hundred years. Soon after the murder of Michael, the Synod of Constantinople pronounced the final separation of the Eastern and Western Churches (869), confirming a spiritual as well as a temporal cleavage. This pronouncement was the outcome of the long-standing quarrel between Rome and Constantinople on the question of authority, which had now reached a climax.

LESSON 6

Feudalism Takes Shape in Europe

In the preceding Lesson it was shown how France and a first vague shape of Germany came into being in 843, by the Treaty of Verdun. At the end of the 9th century Odo was reigning in the West as elected king of the French. The titular king of the Germans was Lewis the Child, a Carolingian great-grandson of the first German king Lewis. Germany included the five dukedoms corresponding to the five German " nations " : Lotharingia, with Friesland (the Netherlands), on the west ; in the centre, from north to south, Saxony, Franconia, and Swabia ; on the south-east, Bavaria. Provence was independent ; Berengar, a Carolingian by female descent, was king of Italy.

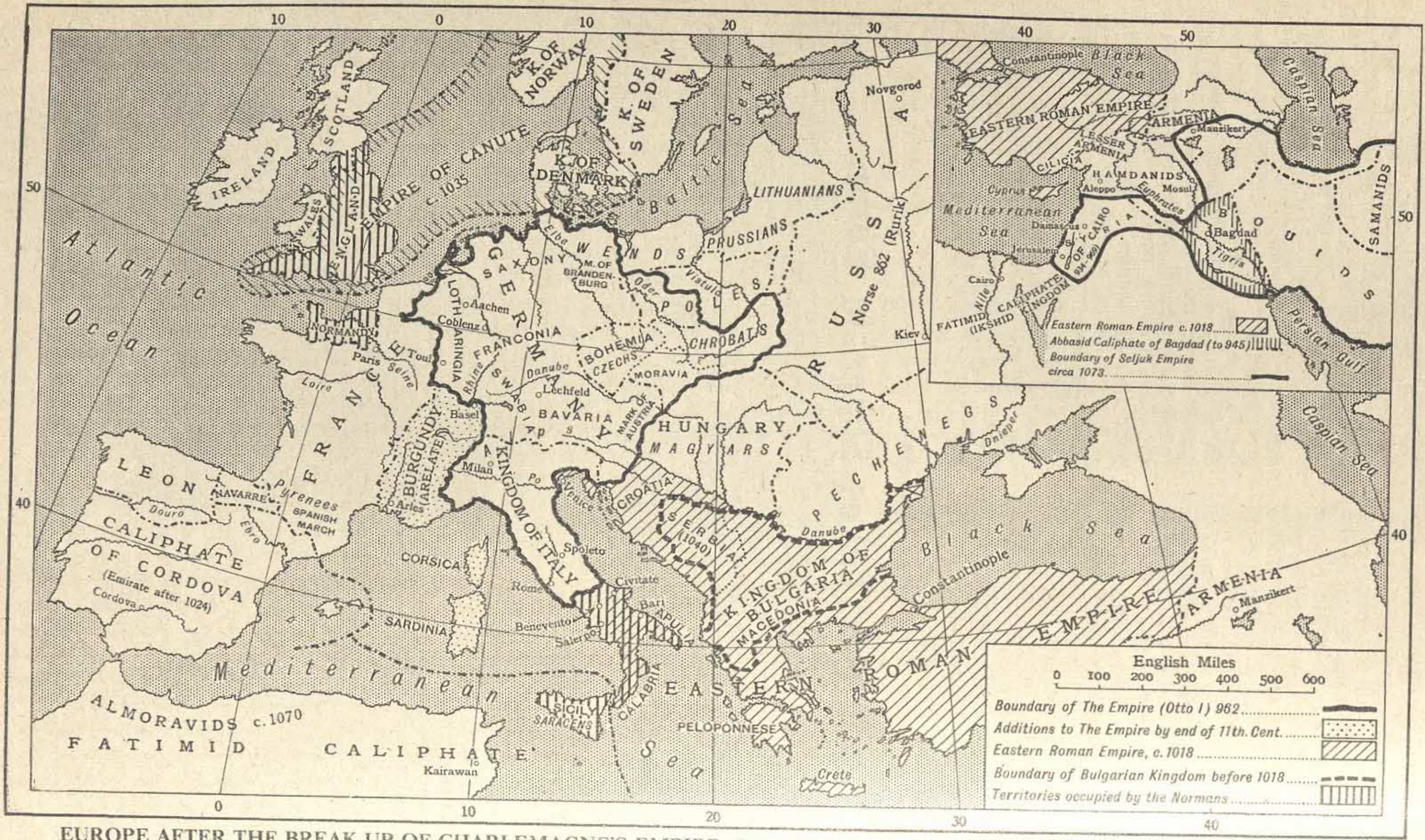
Saracens who did not acknowledge the Baghdad caliphate were still in full possession of Sicily, but Constantinople (or, as it is often called in histories of this period, Byzantium) had recovered its hold on Calabria in Italy. In the unsubdued north of Spain Christian kingdoms were rising and already very gradually pushing back the Moors. The brilliant period of the Moors in Spain was due, as at Baghdad, to a fusion of peoples in which the Arab played a subordinate part ; in Spain, the main factors were African Berbers, Christian Goths, and Jews. While the early caliphs of Damascus took very little interest in letters or philosophy, their descendants of Cordova were distinguished by their culture and support of learning.

The Mahomedan world at this period, with independent caliphs at Baghdad, in Africa, and at Cordova, was too divided to be aggressive in Europe ; and a pedant, Leo VI, reigned peacefully at Byzantium over an empire where the administrative machine ran smoothly without interference. Outside the empire, Danes and Norsemen were continuing their depredations, but these Vikings were independent adventurers, not the armies of the kings of Denmark or of Norway. In England, Alfred had permitted colonies of Danes to settle in the Danelagh. East of the Elbe the Slavonic peoples remained outside the empire ; in Hungary the Ugrians or Magyars, people of non-Aryan or Mongolian stock, had absorbed the Avars and were now threatening Bavaria.

French Dynastic Details

France presents from this time the picture of typical feudal monarchy. Odo was a noble among other nobles ; he was elected king because he had shown himself best able to discharge a critical task at a critical moment. The rest swore allegiance, but his power to control them depended on their own loyalty. When he died, his brother Robert might have secured the succession but chose instead to set the crown on the one available representative of the old royal house, Charles the Simple, who was now (899) eighteen years old. Charles was neither stern nor cunning enough to inspire fear ; in conjunction with Rudolf of Burgundy, Robert, who had been made " duke of France " with greatly enlarged estates, deposed him. Robert was killed in battle, Rudolf was made king, Charles was starved to death in captivity.

When Rudolf died, in 936, Robert's son, Hugh the Great, instead of seizing the crown himself



EUROPE AFTER THE BREAK-UP OF CHARLEMAGNE'S EMPIRE. Particularly noticeable features in this map of 10th- and 11th-century Europe are the Mahomedan dominion in the Iberian peninsula, Gallic France separated from Teutonic Germany by buffer states, and the Eastern Roman Empire stretching south from the Danube. Leon, in north-west Spain, was a Christian state: by 1048 the Christian kingdoms of Castile, Navarre, and Aragon, had emerged and were thrusting back the Moorish power which acknowledged an Ommayad caliphate at Cordova. Northmen or Normans held Normandy, Sicily, southern Italy and, under Canute and after the Conquest, England. The eastern European lands were inhabited by half-savage Magyars, Slavs, etc. The fanatical Seljuk Turks dominated Syria and were on the point of absorbing Asia Minor.

preferred to enjoy the more real power as a sort of mayor of the palace, and he recalled Louis IV, son of Charles, from England to the throne, with the prestige of the Carolingian line. Louis and his son Lothair, who followed him, were both capable and vigorous princes, but both died young. When no Carolingian was left to succeed, Hugh Capet, the son of Hugh the Great, was elected king of France in 987. His dynasty endured with intervals till 1848.

Conditions in Germany

In Germany, Arnulf had been what was most needed, a strong king and emperor, whose supremacy the dukes were ready to acknowledge. Lewis the Child could be no more than a figurehead. The Magyars took their opportunity to make devastating raids ; Lewis died in 911, a year after suffering a heavy defeat at their hands, and the German Diet, following the French example, elected as German king Conrad, count of Lower Franconia. Conrad died in 918, and the Franconians supported the election of the Saxon duke, Henry the Fowler.

OTTO THE GREAT. Son of Henry the Fowler, he made his own family the most powerful in Germany. In 952 he crushed Magyar and Slav invaders. This ivory depicts him as emperor supported by subject princes.

Having no rival whose power he need fear (Berengar was now emperor in Italy, but not recognized elsewhere), Henry was careful to rule the princes rather as president of a confederation than as a sovereign ; he beat off the Magyars and exacted from them a ten years truce ; he founded agricultural colonies, which were also organized commercial centres, between the Elbe and the Vistula. Each colony had a walled town, within which a tenth of the colonists resided to form a garrison. These towns proved effective strongholds against Magyar raids. He strengthened his own duchy by his internal administration. Though never crowned Emperor, he is counted in the list as Henry I.

His son, Otto the Great (912–73), abandoned the cautious policy of Henry. He meant to be a second Charlemagne, a real head of the Holy Roman Empire, with a full appreciation of what that implied. His election was almost a matter of course, but in parts of Germany there was armed refusal to acknowledge a youth of 24. By 941 he had crushed rebellion ; three of the dukes were killed in the process. Otto took the Franconian dukedom, and gave Bavaria to his brother Henry, and Swabia to his own son, thus making his own house far the most powerful.

He appointed Counts Palatine to defend the western frontiers of the empire, and established " marks " or marcher governments to check the Slavs, Magyars, and Italians. For imperial government he relied chiefly on ecclesiastics, who could found no families ; his own brother Bruno, archbishop of Cologne, was one of the eminent men who maintained the prestige of the Church at a time when a succession of unworthy popes had lost the respect of Christendom.

Otto's Mastery

Pope John XII gave Otto the chance to intervene in the government of the Church by appealing to him against Berengar II, king of Italy. Otto had himself crowned emperor in Rome, and then dictated his terms to John (962). Otto deposed John, put in his place a new Pope, Leo VIII, of his own choosing, and left Italy in 967. In 973 he was succeeded by his son Otto II, a youth of 18, for whom he had procured as bride a Byzantine princess, Theophano, with the imperial Italian lands as marriage portion.

When Otto the Great died, he had made the Czech kingdom of Bohemia tributary, and carried the north-eastern bounds of the organized empire from the Elbe to the Vistula. He had reduced the dukes themselves to obedience, he was master of Italy, the clergy were under his control, and the Papacy had recognized his supremacy.

Otto II wished to make Italy, not Germany, the centre of the restored empire. He made his authority decisively felt in Germany ; but while preparing to repeat the process in south Italy, he died suddenly, in 983. He left as his successor the infant Otto III, whose title had already been conferred by the German Diet, and for some years the affairs of the empire were conducted by a regency.

LESSON 7

Early Monarchs of Medieval Europe

WHILE the history of France was moving towards the founding of the Capet monarchy, and the great rulers of the Saxon line were restoring the Holy Roman Empire in Germany and Italy, the Eastern Empire enjoyed a long period of repose and mechanical prosperity, unvexed by the divided Saracen powers, except in Mediterranean waters. A period of revived military activity followed during the minority of the emperors Basil II and Constantine VIII, under the associate emperors Nicephorus Phocas and his nephew and murderer, the Armenian, John Zimisces.

After the death of Romanus II in 963, Nicephorus Phocas married the widowed empress Theophano. Tiring of him, she conspired with her lover, John Zimisces, to effect his assassination. In spite of great military successes—the recovery of Crete and Cyprus and subjection of half Syria—the brutal Nicephorus was unpopular with clergy and court, and his murder was generally condoned. John proclaimed himself, without opposition, associate emperor with Theophano's two children, but Theophano herself was imprisoned in a convent (969).

BASIL II (c. 957–1025). Emperor of the Eastern Roman Empire from 976 till his death, he conquered the Bulgarians so ruthlessly that he was nicknamed "Bulgaroctonus," the Bulgar-slayer. This miniature shows officials of the imperial court kneeling before him.

Under John, Byzantine policy was changed. In 971 he co-operated with Boris II of Bulgaria in repelling an invasion of Russians under their prince Sviatoslav, who ruled the state founded by the Northman Rurik (d. 879) with its capital at Kiev. John beat Sviatoslav in battle twice, and then concluded a treaty with him, by which the Russians became his allies and also converts to the Orthodox Christian faith. Basil, coming of age at the time of John's death, ruled in fact as sole emperor, though in form as the colleague of his brother Constantine, from 976 to 1025.

Basil continued John's work, winning the title "Bulgar-slayer" by reason of a victory which for the time extinguished the kingdom of Bulgaria and added much to the power of the Eastern empire, of which he reorganized the Asiatic portion. Basil left no male heir, and the revived strength of the Eastern Empire died with him in 1025. In 1028 Constantine died, and for the next 26 years the emperors were the three successive husbands of his daughter Zoë. Her sister Theodora reigned for only three years, and in 1057 the Macedonian dynasty ended.

In France, Hugh Capet reigned for ten years (987–997), with less power as the crowned king than he had enjoyed as the king's controller and leader of the baronage. But the dynasty remained sufficiently firm, son succeeding father, each king reigning 30 years or more for several generations without a disputed succession, strengthening itself by alliance with the Church and avoiding direct conflict with the powerful nobles, though exercising little control over them. Thus dukes of Normandy or Aquitaine or counts of Flanders or Anjou became virtually independent princes, ruling over vassals who showed the same spirit of turbulent independence which they themselves were apt to display towards the crown. When the crown came to an infant heir, Philip I, in 1060, the reigning house was, however, too well established for any attempt to set him aside.

In Germany and Italy the reign of Otto III (980–1002) is a curious interlude. A 13 years regency was chiefly directed by bishops. At the age of 16 Otto, a born idealist, fostered and educated by idealists, became the temporal head of Christendom. He set about the realization of his ideals with the self-confidence of an abnormally clever boy. He went at once to Italy to be crowned emperor, taking with him his cousin and friend Bruno. While they were on the way, the Pope died. Bruno was at once made Pope as Gregory V, and the two young men started to establish the kingdom of God upon earth, hand in hand, sharing the same ideals. But Gregory died, and Otto replaced him by another idealist, Gerbert of Aurillac, a reformer of the Cluniac branch of the Benedictine order. Gerbert became pope as Silvester II, and immediately quarrelled with the German bishops.

Otto's own dreams, centred in Italy, were too fantastic to be possible of realization ; he died in 1002, at the age of 22, and Silvester died the next year. Germany's new emperor was Henry of Bavaria, grandson of the great Otto's younger brother.

Henry II was in a stronger position than any other of the German princes. He had no touch of the genius of the Ottos, but he was level-headed, shrewd, resolute, and pious enough to be called "the Saint." Like Henry I, he concentrated on Germany and the working of the political machine, without indulging in any grandiose schemes, but with undeniable success, cultivating the goodwill of the German clergy. He recognized the independence of both Bohemia and Poland, and established friendly relations with King Stephen, creator of the power of the Magyar kingdom of Hungary. Henry's intervention in Italy met with little success, though Germany enjoyed peace and prosperity under his cautious sway.

TRACTANDO IUSTUM DISCERNITE SEMPER HON SIV
QUILE CONUENIAT CONSVLTUM LEGIS UT OPTAT

HENRY II (973–1024). German king, elected emperor in 1002, he was an able ruler and so devout that he was called "the Saint" and was canonised in 1146. This miniature shows him and his consort being presented to Christ by Saints Peter and Paul. Below, Germany between Rome and Gaul.

Salian Dynasty Founded

Henry was the last of the house of his namesake, the Fowler. He was succeeded by Conrad II (*c.* 990–1039), the Salian, of Swabia, who founded a new dynasty. In the 15 years of his rule Conrad increased the power of the crown as against that of the dukes and counts, by multiplying nobles of secondary rank who had no overlord but himself; he partly established his authority in northern Italy, and, despite his own unpopularity, left the succession secured to a young son trained for his great and difficult position.

Henry III the Black was 21 when he succeeded Conrad, and only 30 when he died. He combined his father's practical qualities with the lofty ideals of an Otto. He raised the empire to a height of power unknown since the time of Charlemagne. Conrad had recovered some authority over Bohemia and Poland ; he had also acquired the crown of Provence, which, commonly spoken of as the Arelate, or kingdom of Arles, remained an integral part of the empire for some centuries. Disorders in Hungary after Stephen's death, and the aggressiveness of Bohemia, compelled Henry III to spend the first years of his reign in reducing them to the status of dependencies outside the imperial system. His prestige was increased by his generous treatment of his enemies, who could not ascribe it either to cunning or fear.

Henry III's Papal Policy

Having established an unusual concord Germany, Henry turned in 1046 to Italy and t Papacy. Conrad had restored imperial autho ity in the north of this peninsula, but in t south the Greeks and the Lombard dukes we in perpetual conflict, while the enmity of Saracens and Norman adventurers complicated the situation.

Italian nobles, who could afford to disregard or defy Conrad, became discreet when Henry crossed the Alps. Henry assumed supreme authority as a matter of course, summoned two synods, and after himself appointing in succession two zealous Cluniacs, both of whom died, nominated as Pope his cousin Bruno, bishop of Toul, who accepted the sacred office only after he had received full canonical election. Bruno, as Leo IX, inaugurated a new line of Popes devoted to the Cluniac doctrines, and a new era in the history of the Papacy (1048).

Henry at the time of his early death was at the height of his power, but he had not consolidated his work, and he left behind him an infant heir. The next generation was to witness the opening of a prolonged and bitter conflict between the temporal and spiritual powers for supremacy in both spheres.

LESSON 8

Dawn of the Age of Chivalry

The last years of the emperor Henry III the Black inaugurated an era to which various names are given. It was coloured by the conflict of the empire with the Papacy ; it is also called the Crusading Era, or the Age of Chivalry. For about two and a half centuries a new importance attached to the personality of the popes and the claims of the Papacy.

By 1048 Spain had seen the emergence of the Christian kingdoms of Castile, Navarre, and Aragon, which had not yet absorbed the Carolingian county of Catalonia or Barcelona. These kingdoms were pushing back the Moorish power, which acknowledged an Ommayad caliphate at Cordova. In France the Capet monarchy was established but its power was very circumscribed. The Arelate and the Rhineland were attached to the empire. Scandinavia stood outside the general European system. Knut (Canute) had failed to consolidate an Anglo-Scandinavian empire, and Edward the Confessor (*c.* 1005–66) was on the English throne.

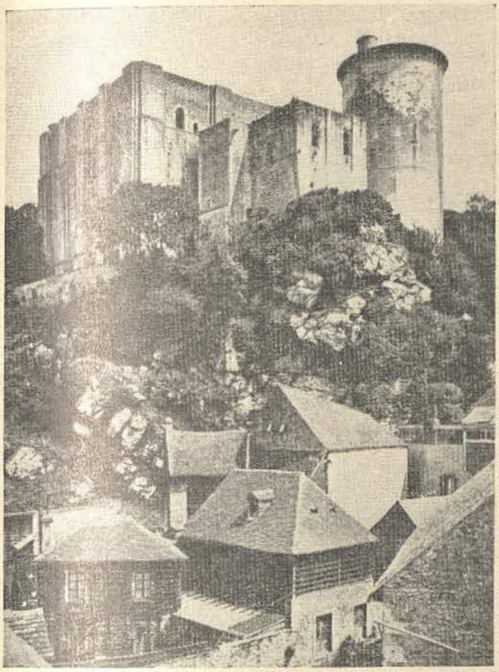
The dominion of the German king extended from the Rhineland to the Slavonic marches ; in his capacity as emperor he was sovereign of Italy, though the Greeks in the south still acknowledged the Byzantine sovereignty. Saracens who acknowledged a Fatimite caliphate in Egypt were in full possession of Sicily. At Byzantium the Macedonian dynasty was flickering out in a melancholy decadence.

In Asia there was still an Abbaside caliph at Baghdad, but he was a puppet in the hands of the barbarian Seljuk Turks, the most fanatical of the peoples who had embraced Islam. These Turks now dominated Syria, and threatened almost the whole of Asia Minor. Palestine was still in the hands of the tolerant Egyptian caliphate, and streams of Christian pilgrims from the West visited the Holy Places. The Seljuk conquest of Jerusalem in 1076 was to be made the occasion, though it was not the cause, of the first Crusade.

Line of Cluniac Popes

In the five-and-twenty years after the accession of Leo IX in 1048, a series of Cluniac popes restored the lost moral ascendancy of the Papacy, giving new force to its claim to the spiritual

CONQUEST OF BRITTANY. After forming part of the Carolingian dominions Brittany was relinquished to the Northmen by Charles the Simple in the 10th century. In 1064 the Bretons accepted the suzerainty of William, Duke of Normandy (afterwards William I of England). In this scene from the Bayeux tapestry the Breton duke, Conan II, surrenders the keys of the castle of Dinan to the Norman besiegers.



THE CONQUEROR'S BIRTHPLACE. It was at the castle of Falaise that Arletta, the tanner's daughter, bore to Duke Robert in 1027 the illegitimate son who was to become William the Conqueror.

sovereignty of Catholic Christendom. The Papacy did not yet challenge the imperial authority, Henry III and Leo being in complete harmony, though Leo had refused to accept the emperor's nomination as valid without canonical election by the Church.

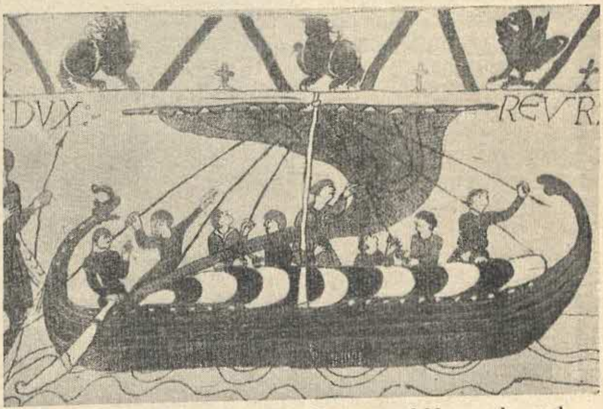
But the right of the emperor to require that a pope's election should be submitted for imperial ratification, which had been recognized since the days of Otto the Great, was ignored in 1062 at the election of Alexander II, when Henry IV was 12 and the German government was in the hands of a regency. The indignant anti-Cluniac German ecclesiastics disputed the validity of the election and procured that of an antipope, Honorius, who, however, was practically unrecognized outside Germany. The fact of such an election was significant although the inevitable clash was delayed until Alexander's successor was on the papal throne.

The Cluniac monks had the loftiest conception of the clergy as the organized servants of God consecrated to the establishment of the kingdom of God upon earth, having as their head the divinely appointed successor of St. Peter. Divine authority of the Church over the laity was the logical consequence, but to justify that authority the Church had to show itself worthy. The reforming emperors, from Otto I to Henry III, had worked in harmony with the Cluniac popes of their own appointment, but the line of Cluniac popes which began with Leo IX saw a need for establishing for themselves a temporal authority independent of imperial support ; the only available basis of such an authority was their sovereignty in the patrimony of St. Peter, the central Italian provinces bestowed on them centuries before by Pepin and Charles the Great.

Norman Adventurers

Their most effective move to secure temporal power was alliance with the Norman adventurers, descendants of the Northmen who had settled in Normandy under Rollo. The Normans had made themselves a force in the European system. They were warriors, adventurers, lawyers, the strictest of overlords, and the most turbulent vassals ; ambitious and greedy, they were also punctilious in their regard for the Church and the outward requirements of piety. The Cluniac reformation reached Normandy in 1001, and in the next 60 years many monasteries were built. Normandy offered no scope for adventure, and from there the Normans went abroad in search of it.

Scenes from the famous Bayeux tapestry illustrate Norman activities at this period, when their duke William—William the Conqueror—was about to lead them to conquer England, after having already conquered Brittany. For half a century before the battle of Hastings (1066) Normans had swarmed into south Italy, the most distinguished of them being the numerous brothers of the Hauteville family. By the middle of the century, with the emperor's



NORMANS AT SEA. The Normans of Normandy used ships of virtually the same build as those of their Northmen forebears. The vessel seen in this piece of the Bayeux tapestry is carrying Normans across the Channel to England.

acquiescence, they had secured the counties of Apulia and Capua, and were more powerful than any of the Lombard dukes or their Greek rivals.

When Leo became Pope he regarded the Normans as a menace, came into collision with them, and suffered an overwhelming defeat ; but the Normans behaved with astute magnanimity. They wanted not humiliation of the Papacy, but alliance with it. In 1059, under Leo's successor, Nicholas II, the alliance was struck. Robert Guiscard, head of the Hautevilles, received as papal fiefs the dukedoms of Apulia and Calabria, and also the island of Sicily—when he should recover it from the Saracens. In 1071 his younger brother Roger began the long process of conquest. In the same year Robert expelled the Greeks from Bari, their last stronghold in Italy. In that year, also, the Eastern emperor Romanus was overwhelmingly defeated by the Turk Alp Arslan, and all but a fragment of Asia Minor was turned into the Seljuk sultanate of Roum.

The prestige of the Papacy in 1073, when Alexander II had died, was probably higher than it had been at any time since the death of Pope Gregory I. The man who had stood beside, and perhaps inspired the policy of, every pope for five-and-twenty years was the cardinal-archdeacon Hildebrand, who became Gregory VII by popular acclaim. The emperor Henry IV ratified the irregular election. But in 1075 Gregory threw down a challenge which the young emperor, elated by victory over the Saxons, was prompt to take up.

LESSON 9

The Papacy and the First Crusade

With the accession to the papal chair of the greatest of the popes, Gregory VII (also known by his name Hildebrand), in 1073, the idea of papal supremacy reached its highest development. After two centuries, during which Rome seemed to be sinking into degradation, and was at one time in danger of capture by Saracens, the European rulers and clergy recognized that the fall of the Papacy would leave nothing to take its place, and that the bishop of Rome must be reinstated in full dignity. There was a widespread desire for ecclesiastical reform ; the strength of Gregory VII lay both in his recognition of this desire and in his practical wisdom. His political insight had shown itself in his support of the Normans in Sicily and England ; he gave his blessing to William the Conqueror. The Normans were prime movers in the First Crusade.

Rex rogat Abbatem Mathildim supplicat atq;

HENRY IV AT CANOSSA. In 1076–77 the Papacy triumphed briefly over the Empire. The Emperor Henry IV abased himself at Canossa before Gregory VII and submitted to the papal demands.

Gregory wanted in effect to replace the Holy Roman Empire by a United States of the World with the Pope as supreme head over kings and rulers. He also attempted to re-establish the purity of the monastic ideal, and to abolish simony (corrupt practice by which a person is presented for ecclesiastical preferment in return for a reward). He enforced celibacy on the clergy, and attacked the system of lay investiture which made bishops the feudal tools of kings. The spiritual obedience of bishops and abbots was due to the Pope, but as territorial magnates they were responsible to the head of their state.

Princes sometimes not only made their own ecclesiastical appointments but also conferred spiritual authority by investing their nominees with the symbolical ring and crozier in spite of protests from less complaisant churchmen. In 1075 Gregory pronounced excommunication against all who conferred or received lay investiture. The emperor Henry IV retorted by investing a new archbishop of Milan, and followed this up by declaring Gregory's deposition from the Papacy by his own imperial authority.

Gregory summoned the emperor to appear before him to answer for his crimes, and on his refusal absolved all Henry's subjects from their oath of allegiance, excommunicating him, and finally calling on the Germans to elect a new emperor. Panic-stricken by signs of revolt in Germany, Henry repaired to Canossa, in the domain of Gregory's devoted adherent, Matilda of Tuscany, where the pope was that winter staying. According to a picturesque but not too well substantiated account, for three days the emperor stood in the snow, a penitent clad

CRUSADING ARMOUR. An elaborately illuminated psalter (c. 1260) gives the military costumes of the crusading age ; an inscription on the fly-leaf states that it first belonged to St. Louis (Louis IX of France), leader of the crusade that came to grief in Egypt after capturing Damietta. The scene on the left is intended to show Abraham smiting Amraphel and his confederate kings ; on the right, the Israelites are capturing a city while sun and moon stand still at Joshua's command.

only in his shirt, knocking vainly at the gate of the castle for admittance to receive forgiveness. On the fourth day he made submission to Gregory.

Rival Emperor and Pope

Such depths of humiliation, however, produced a reaction not only in Henry but in public opinion in Germany. Gregory's pride had overreached his wisdom. Within a month the emperor was planning to overthrow his humiliator. He returned to the practice of lay investiture ; Gregory renewed the excommunication, and a rival emperor was elected. Germany was plunged into civil war, and Henry's rival was killed in battle ; a second rival was elected but received only half-hearted support. The German and Lombard anti-papalists elected an anti-pope.

For three years Henry besieged Rome ; when the city was betrayed to the enemy Gregory retired to the impregnable castle of St. Angelo. Henry set up the rival pope, Clement ; he had not yet been crowned emperor, and Clement repaired the omission. In 1084 Guiscard returned with a mixed army of Normans and Saracens, drove Henry out, sacked Rome, and took Gregory to safer quarters at Salerno, in the south, where he died in 1085. Rome was left half ruined and almost deserted.

The papalists, who refused to recognize the anti-pope Clement, found another uncompromising leader in Urban II, elected to the Papacy in 1088. The emperor was too deeply involved with his German rebels, among whom was his son and heir Conrad, to take decisive measures in Italy ; and then an opportunity was offered to Urban which he grasped with both hands.

Alexius Comnenus

In 1081 an able and astute emperor, Alexius Comnenus, assumed the diadem at Constantinople. He wanted aid from the West to recover the lost dominions in Asia. No one in the West cared about the Eastern empire, but Comnenus recognized the power of piety among rough western nobles, and knew that they might rise to the idea of a Holy War against the infidel. The Turks, in possession of the Holy Sepulchre, were persecuting pilgrims as the more civilized Arabs had never done. These persecutions gave Alexius the excuse he needed. No lay ruler or potentate had prestige or leisure to organize a war for the Cross against the Crescent ; Alexius appealed to Urban. By

THE GOAL OF THE CRUSADES. The Church of the Holy Sepulchre in Jerusalem was founded in 335 by Constantine and rebuilt by the Crusaders.

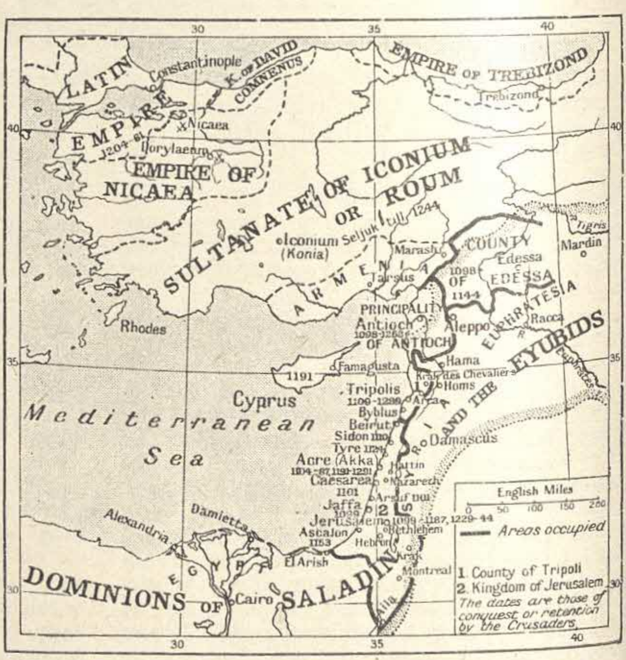
answering the appeal the Pope assumed the leadership of Christendom.

A Council of the Church was summoned (1095) to meet at Clermont. A vast lay multitude also assembled, nobles and knights and commoners ; and when, in an atmosphere of passionate emotion, Urban made his final fervent appeal, the universal cry rang out—*Deus Vult* (It is the will of God). The First Crusade was launched, by a united Christendom, and the man who had united it was not the emperor, as in past times, but the Pope. The first wave of Crusaders, under Peter the Hermit and Walter the Penniless, consisted of ill-armed enthusiasts, who disgraced the Cross by savage misbehaviour all across Europe, and were annihilated in Asia Minor. In 1097 a host of regular troops gathered at Constantinople and crossed into Asia. In 1099 Urban died, and the Crusaders captured Jerusalem.

Meanwhile Henry IV was ruined. Rebellion was endless, and every rebel made the excommunication his warrant. The sentence was never withdrawn. Conrad died, but when Henry himself died in 1106 he had already been practically deposed by his second son and successor, Henry V, between whom and Urban's successor, Paschal II, the struggle was renewed. It went on unabated till in 1122 the Concordat of Worms required ecclesiastics to render homage and service for their lands, but retained for the Church their investiture with the symbols of their spiritual office. The basic question of supremacy as between emperor and Pope was left untouched.

After the First Crusade was launched, Alexius hoped for a substantial force from the West which he could turn to account for the recovery of more than Asia Minor, faction being rife among the Turks. The army which assembled at Constantinople had other views. Half its leaders hoped to carve principalities for themselves out of Asia, and the other half had Jerusalem as their single objective. Asia Minor had first to be cleared and handed over to Alexius, but once past the Taurus their obligations to him ended ; and there was no single leadership. After a long and desperate siege Antioch fell to Bohemund of Tarentum, Robert Guiscard's second son. A depleted force under Godfrey de Bouillon finally stormed and captured Jerusalem. Feudal theory required that the conquest should be organized as a kingdom of Jerusalem ; Godfrey was elected and accepted the office but refused the title and royal crown. He adopted the designation of " Advocate " of the Holy Sepulchre.

The Latin Kingdom was a narrow strip of coastal territory extending from Ascalon and Jerusalem to Antioch and thence to Edessa.



THE LATINS IN PALESTINE. This map shows the strategic weakness of the Crusaders' territories in and near the Holy Land. The Latin kingdom was little more than a narrow coastal strip with a short-lived extension about Edessa.

The kingdom consisted, in fact, of a long line of fortresses with some ports, including Acre (captured in 1104), and a small permanent garrison mainly consisting of the two new orders of military monks—the Templars and the Knights of St. John. A line of such length so sparsely garrisoned could hardly escape penetration if the Moslems should concentrate attack. And so, though the kingdom held its own for 45 years under its elected kings, Baldwin I, Baldwin II, and Fulk of Anjou, its great northern outpost, Edessa, was captured by the Turks in 1144. This event opened the second period of the Crusades.

LESSON 10

Political Faction in the 12th Century

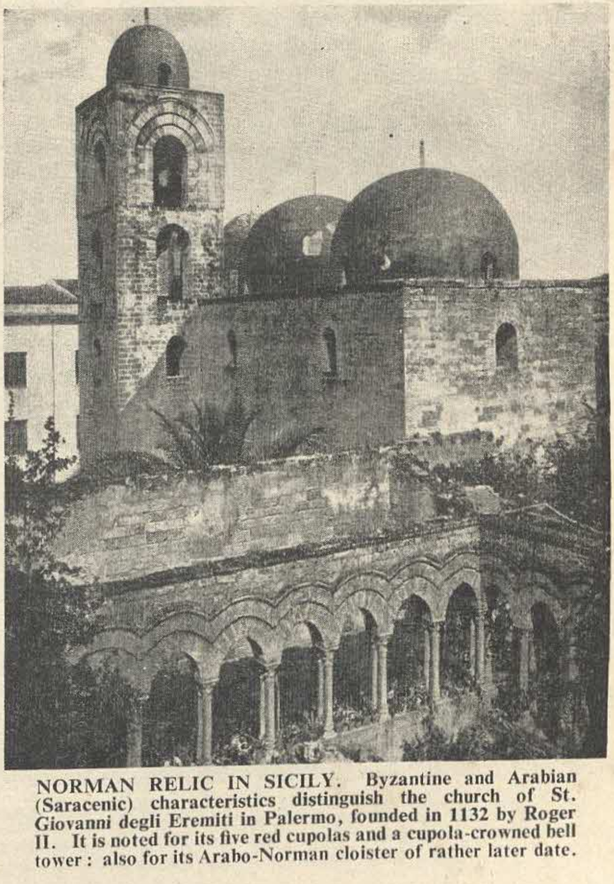
On the death of Henry V, in 1125, without a direct heir, the Saxons and Bavarians secured the imperial succession for Lothair of Saxony, the defeated candidate being Henry's nephew Conrad of Weiblingen (the name later corrupted into Ghibelline) and Franconia. Lothair was elderly and had no male heir ; but Henry the Proud of Bavaria, of the House of Welf (later corrupted into Guelph), was his son-in-law. The rivalry between the Ghibellines and the Guelphs was a primary source of trouble through the next 150 years. Lothair died in 1137 ; war prevented Conrad's succession until 1143.

Norman Sicily

The influence of the Papacy had declined owing to internal dissension ; Roger II of Sicily, nominal vassal of the popes, had wrung from them the title of king, and added to his family dukedoms of Apulia and Calabria most of the counties of south Italy. The kingdom of Roger has been called the first modern state ; but it was like no other state in history. Into the strange medley of Greek, Saracenic, and medieval Italian institutions the Normans introduced the feudal system of the North, with the Byzantine addition of divine right of the ruler. Norman rule was, however, in the main tolerant, interfering little with local customs and conditions. Under Roger II, French was the court language, but Sicilian culture was for a time cosmopolitan ; the king had a passion for geography fostered by Idrisi, an Arab scholar from Spain. The chief literary figures were Greeks ; the architect of the church of La Martorana at Palermo was George of Antioch, one of Roger's admirals, a Saracen who had embraced Christianity.

The church of San Giovanni at Palermo is another splendid example of Arabo-Norman culture. Palermo remained a Saracen city upon which Norman colour had been laid ; Messina became Latinised over a Greek substructure. Roger planted agricultural colonies of Italians, organized into communes, here and there in the island. Some of the colonists were Italians from northern Italy (there are still places in eastern Sicily where a dialect with western Lombard elements is spoken).

At this time England was passing through the appalling anarchy of Stephen's reign. In Spain, Crusaders fought the Moors as an alternative to fighting Saracens in Syria. In 1144, Europe was startled by the fall of Edessa. The voice of



NORMAN RELIC IN SICILY. Byzantine and Arabian (Saracenic) characteristics distinguish the church of St. Giovanni degli Eremiti in Palermo, founded in 1132 by Roger II. It is noted for its five red cupolas and a cupola-crowned bell tower: also for its Arabo-Norman cloister of rather later date.

Bernard, abbot of Clairvaux, the most powerful spiritual influence of the day, was raised to call Christendom to a new Crusade.

The Second Crusade

Louis VII of France eagerly, and the emperor Conrad reluctantly, answered the appeal. Conrad gathered an army, would not wait for Louis, and passed into Asia Minor by agreement with the Eastern emperor Manuel Comnenus (1148). Louis followed next year, and was joined by Conrad, who had suffered disaster in the mountains of Roum. A portion of the combined force reached but failed to take Damascus, and the remnant escaped ignominiously out of Asia. Thus ended in failure the Second Crusade.

Frederick Barbarossa

In 1152 Conrad died ; and the rivalry of the two great houses was for the time stilled by the election of his nephew Frederick of Swabia, called Barbarossa, whose mother was a Guelph. Frederick was the only leader to win distinction in the Second Crusade. In the first two years after his accession he pacified the unruly Germans, but he was not satisfied to be German king ; conviction of imperial responsibility urged him to restore imperial power and dignity.

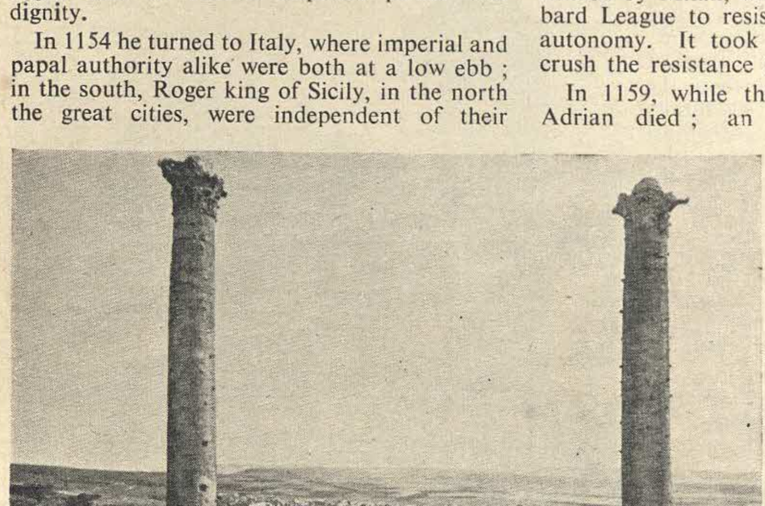
In 1154 he turned to Italy, where imperial and papal authority alike were both at a low ebb ; in the south, Roger king of Sicily, in the north the great cities, were independent of their nominal overlords ; Rome had set up its own commune, repudiating papal sovereignty. A sequence of inefficient popes had, however, now come to an end with the election of the one Englishman to occupy the papal throne — Nicholas Breakspear (a native of Hertfordshire), who became Adrian IV and upheld every claim that Gregory VII himself had ventured to make.

BARBAROSSA. Frederick I (c. 1124–90), the German king who was nicknamed after his red beard, was crowned emperor in 1155.

The pacification of Germany was not yet complete, and the emperor had to hurry back over the Alps. In 1158 he returned to Italy, primarily to enforce submission of the cities, headed by Milan, which had formed the Lombard League to resist encroachments on their autonomy. It took Frederick three years to crush the resistance of Milan.

In 1159, while the struggle was going on, Adrian died ; an avowed anti-imperialist, Alexander III, was elected as his successor.

Four years later the League revived under new leadership. In 1166 Frederick Barbarossa swept down on Rome ; the Pope excommunicated him and fled to the Normans in the south. But the army was smitten by a pestilence so terrible that Frederick could only retreat with the survivors. Papal anathemas encouraged disaffection in Germany. The Guelphs were papalists by tradition ; the loyalty of Frederick's cousin Henry the Lion, duke of Saxony, was doubtful, and Henry was lord of nearly half Germany, as his father-in-law Henry II of England was lord of half France (to the great



CRADLE OF EASTERN CHRISTIANITY. The Second Crusade resulted from the fall of Edessa (1144), the modern Urfa in north-west Mesopotamia. In the second century B.C. the city had been the seat of a local dynasty; one of its kings raised the pillars seen in this photograph.

inconvenience of King Louis VII); papalist sympathy was growing among the German clergy. Not till 1174 could Frederick venture on a return to Italy; the League and Alexander were stronger and more determined than ever. After two years' campaigning Frederick's army was shattered in battle at Legnano, where the infantry withstood the charges of his mail-clad cavalry and finally routed them (1176).

Frederick had believed in the righteousness of his cause; Legnano convinced him that he had been in the wrong. Being a great man, he dared to admit the fact and ask pardon of the pope. Alexander was a great man, too, and understood him. Their long negotiations resulted in the Treaty of Constance, 1183. Full autonomy was restored to the cities, which continued to owe a nominal allegiance to the emperor.

When Barbarossa returned to Germany the breach between him and Henry the Lion soon developed into open war. Despite the surrender in Italy, which would have been fatal to a smaller man, the emperor was completely victorious. Henry was left little more than Brunswick; Bavaria went to the Austrian Wittelsbachs, and half Saxony to the margrave of Brandenburg. It seemed that the emperor was to end his days in peace, but the East called him again; in 1187 the Seljuk sultan, Saladin, captured Jerusalem, and Barbarossa took the field in the Third Crusade.

LESSON 11

Conflict in East and West

SALADIN (1137–93), an orthodox adherent of the caliphate of Baghdad, made himself master and sultan of Syria when the Latin kingdom in Palestine was rent by a disputed succession; Guy of Lusignan had secured the crown, but the kingdom was divided. Unlike his predecessors, Saladin intended to drive out the infidels, having already overthrown the Fatimite caliphate in Egypt. In 1187 Saladin shattered the Latin army, and took Guy prisoner at the battle of Hattin or Tiberias; four months later he captured Jerusalem. Antioch, Tripolis, and Tyre held out, but the Latin kingdom of Jerusalem was almost extinguished. Nothing was to be hoped from Constantinople, where the dynasty of the Comneni had been succeeded by the Angeli; Isaac Comnenus, however, ruled Cyprus, where he called himself emperor.

SALADIN. Born 1137, son of a Kurdish governor of Damascus, Saladin was so successful in war with the Egyptians that he was made vizier in 1170. In 1175, after the death of Nur-ed-din, Sultan of Syria, he made himself master of the realm.

Third Crusade

The news of the capture of the Holy Places rang like a bugle-call through Europe, but dissensions delayed a united movement from the west. When Frederick Barbarossa had gathered his great German force early in 1189, the rest were not ready. He took the usual overland route, and in 1190 was marching victoriously through Asia Minor. There he was drowned while trying in sport to swim a river. Without its leader the army went to pieces; many men returned home, plague broke out among the remainder, and only a few ever reached the Crusaders in Palestine. They found them besieging Acre, which had fallen to the Saracens. Saladin attempted to relieve the defenders, without success, and Acre was retaken by the Crusaders in 1191.

The Crusade failed because of the dissensions of its chiefs. Richard Coeur-de-Lion had many of the qualities of a great general—qualities which excited the admiration of the Saracens—but arrogance and recklessness made him impossible as a colleague and intolerable as a chief. Kings and princes discovered an imperative need for their return home; Philip II of France led the way. Twice Richard brought the Crusading host to within a few miles of the Holy City, but the remaining German and French contingents failed to support him, and he was obliged to retreat.

In 1192 he abandoned hope of a reconquest, and signed with Saladin the treaty which left the Turk in possession of Jerusalem and all Palestine except certain ports. The peoples of the West were to be at liberty to make pilgrimage to Jerusalem, free of the taxes which Saracen princes had extorted from them. There were several Crusades during the next century,

CRUSADING PILGRIMS. Taken from a manuscript account of the travels of Sir John Mandeville, this illustration shows pilgrims paying toll at Joppa or Tyre.

but there was never again even the pretence of a united effort of Christendom. The fourth Crusade turned upon the heretical Greeks and established the short-lived Latin empire in Constantinople, together with nominal supremacy of the Papal See over the Eastern Church.

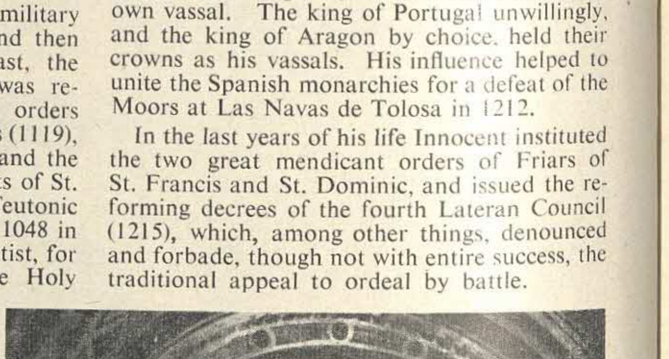
Though the Crusades were essentially military expeditions, aimed first at conquest and then at support of Latin states in the East, the central motive of these movements was religious. Two great military-religious orders were established : the Knights Templars (1119), to protect pilgrims in the Holy Land, and the Hospitallers, which included the Knights of St. John of Jerusalem, and, later, the Teutonic Knights. This group originated about 1048 in a hospital dedicated to St. John the Baptist, for the care and cure of pilgrims to the Holy Sepulchre. Later the order became military, and like the Templars its members were sworn to protect the Holy Sepulchre itself.

Frederick Barbarossa had procured the coronation of his son Henry as German king and king of the Romans, and on his own departure on the third Crusade left Henry behind as indisputable viceroy. The assumption was that the king of the Romans was the recognized heir to the empire, though not technically emperor till his official coronation at Rome. Henry VI was 25 when his father died. During his brief reign (1190–97) he strengthened his hold on Germany. When Richard Coeur-de-Lion, on his way from Palestine, was delivered into Henry's hands, Henry extorted homage from him, reducing England temporarily to vassalage, as a condition of release.

In Italy, Henry failed to eject his wife's illegitimate nephew Tancred from the throne of Sicily and Naples, to which he had been elected on the death of King William, but when Tancred himself died Henry established his own authority as the husband of the Norman Sicilian princess, Constance, by methods as offensive to her as to the Sicilians—methods which made the German ascendancy detestable to the entire south. His career, however, was cut short by his death at 32, leaving as his heir the two-year-old infant who was to become famous as Frederick II, *Stupor Mundi* (the Wonder of the World). At almost the same time Innocent III was elected Pope ; Constance placed her child under Innocent's guardianship.

The Papacy under Innocent attained the zenith of its power. Innocent claimed more than any of his predecessors had claimed —a divinely ordained supremacy over all temporal potentates. As Frederick's guardian and suzerain he ejected the German overlords forced by Henry VI on Sicily and Naples. He deposed King John in England, and reinstated him as his own vassal. The king of Portugal unwillingly, and the king of Aragon by choice, held their crowns as his vassals. His influence helped to unite the Spanish monarchies for a defeat of the Moors at Las Navas de Tolosa in 1212.

In the last years of his life Innocent instituted the two great mendicant orders of Friars of St. Francis and St. Dominic, and issued the reforming decrees of the fourth Lateran Council (1215), which, among other things, denounced and forbade, though not with entire success, the traditional appeal to ordeal by battle.



INNOCENT III (1160–1216). Educated at Rome, Bologna, and Paris, he held various offices in the papal court before he succeeded Celestine III in 1198. He devoted himself to the restoration of the temporal power of the Papacy.

LESSON 12

"Stupor Mundi," his Achievements and Significance

Crafty, resolute, unscrupulous, a capable soldier and a born organizer, Philip II (1165–1223) made himself king of France in a sense which had been true of none among his predecessors, though he had to wait for full success till the death of his formidable feudatory Richard, duke or count of half France, and king of England. For generations the Capet kings had been weakening a too powerful baronage by fostering internecine feuds, encouraging the development of free cities or communes, choosing clergy or minor barons for administrative posts, and seizing every opportunity, whether by forfeitures or marriages, to add to the royal estates. The policy had a serious set-back when Henry of Anjou, later Henry II of England, married Eleanor of Aquitaine and trebled his already wide dominions.

France Gains Normandy and Anjou

While Richard was in Palestine or a prisoner, Philip schemed against him with his brother John. When John succeeded Richard on the English throne Philip saw his chance, and at the end of a five years' conflict Normandy and Anjou became appanages of the French crown. John was left with little more than Guienne and Gascony. The royal estates in France were now wider than those of all the feudatories put together.

BLANCHE OF CASTILE. Widow of King Louis VIII, she proved an able regent for her son Louis IX.

Philip's son, Louis VIII (1187–1226), in his short reign carried on his father's policy, but at his death provoked future trouble by bestowing out of the royal domains great appanages—Artois, Poitou, and Anjou—on his three younger sons. The eldest, Louis IX, was only 12 ; the successful regency of Louis's mother, Blanche of Castile, in the face of a strong feudalist reaction, proved her remarkable abilities as a ruler. In the son to whom she resigned the reins of government in 1235 the world found the *beau ideal* of a medieval Christian king—a prince who sought no honour for himself but won it in the eyes of all men ; a knight without fear or reproach, and without either feeble pietism or fierce fanaticism.

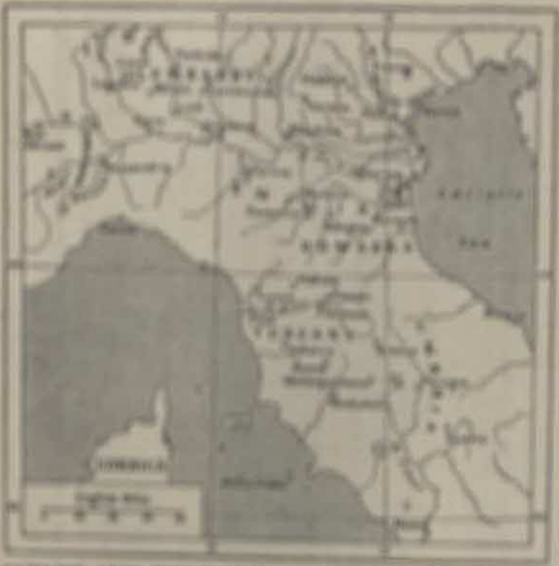
In the strongest possible contrast to Louis was his contemporary the emperor Frederick II. Frederick was born out of due time, anticipating all the spirit of the approaching Italian Renaissance. His versatility and his brilliance astonished his own age. He was a rationalist who regulated his life by astrology ; a student of every known science ; a poet who popularised the vernacular poetry of Sicily by writing it himself ; a sceptic who persecuted heresy and was in perpetual conflict with successive popes. In relation to women his principles and his practice were more Oriental than European. He was no soldier, and was excommunicated for evading his promises to lead a Crusade ; yet he crowned himself king of Jerusalem with his own hands.

FREDERICK II (1194–1250). Son of the emperor Henry VI, he was crowned German king in 1215, emperor in 1220.

He established a system of absolute monarchy in Naples and Sicily, but he deliberately turned Germany into a confederation of virtually independent princes owing hardly more than a nominal allegiance to the emperor. His university of Naples was the first founded by royal charter.

Frederick II and the Papacy

Pope Innocent III, a year before his death, had crowned Frederick German king after receiving a solemn pledge that his kingdom of Sicily should not be united to the empire and that he would devote himself to a new Crusade. Honorius III, who succeeded Innocent in the papal chair, was less masterful. Frederick put Honorius off with fair words and plausible excuses—he must have his turbulent Sicilian kingdom in thorough order before he could take in hand such a Crusade as the circumstance demanded. He had his young son Henry crowned king of Sicily as the Pope's vassal, but he also had him crowned king of the Romans. He soothed Honorius by making large concessions to the clergy, strengthening their hold on the free cities, while he avoided any measures that might offend the German princes. Not



GUELPH AND GHIBELLINE. The development of the Communes led to bitter factions over Italian leagues. Florence and Lucca were Guelph; Siena, Pisa, Parma, and [illegible] were Ghibelline.

without difficulty he suppressed the still strong Saracen element in Sicily.

Honorius died. His successor was Gregory IX, who was not to be put off by promises. To appease him Frederick had to gather a Crusading force, even to set sail. But he had hardly sailed (in 1227) when he returned to port, and Gregory promptly excommunicated him. Frederick set out again, though under the papal ban; he wanted the crown of Jerusalem, having just made its titular queen, Yolande of Brienne, his second wife. Frederick's diplomacy won him the prize without fighting. He took the crown from the altar of the Holy Sepulchre, left a small garrison, and returned to Europe. A few years later another infidel reconquered Jerusalem.

There was a formal reconciliation (1230) with Gregory, which both Pope and emperor meant to be no more than truce. But it lasted 10 years. Frederick's son Henry, left in Germany, had been making trouble there. Frederick wanted a free hand in Italy, and dropped the previous German policy of strengthening the clergy, the towns, and the lesser barons against the princes. He now needed the good will of the great ducal houses; accordingly he issued the Charter of the Princes, which made them all but independent sovereigns. When his son Henry persisted in his opposition Frederick deposed him and procured the election of Conrad, his son by Yolande, as German king. Then he returned to Italy (1237) to deal with the city leagues.

Guelph and Ghibelline

The cities which Barbarossa had left as free republics were constantly torn by internal factions and external rivalries, but had a common desire to shake off the last shreds of imperial control. They were Guelph or Ghibelline, papalist or imperialist, according to the policy of the temporarily dominant faction. Frederick meant to bring them all under his own

YELLOW PERIL OF THE MIDDLE AGES. Temujin (1162–1227), son of a petty Mongol chieftain, built up a great empire in Asia. In 1206 he proclaimed himself Jenghiz Khan, or "perfect warrior emperor"; the scene is depicted in this illustration from a MS. of Rashid-ud-Din, written about 1310.

general support; to that end he encouraged the rise of despotisms whose despots would seek support from him. In 1237 he won a victory which broke up the Lombard League and brought him again into collision with his old enemy Gregory. Gregory escaped him by dying. The conflict was renewed by Pope Innocent IV; Germany was plunged into a struggle between Conrad and a rival German king, William of Holland; Guelphs and Ghibellines fought and intrigued in Italy; and while the confusion was at its height Frederick died (1250).

In spite of the political degeneration of his time Frederick's reign has great historical and some literary significance. The expansion eastwards of his empire continued unchecked, mainly owing to the activities of the Teutonic Knights. It was the age of minnesang, the lyrical reflection in the German romances of Parzival and Tannhäuser. There was much intellectual activity, foreshadowing the revival of learning throughout Europe.

Frederick's interests were always bound up in Sicily, where he developed his revolutionary schemes, creating an absolutism, an oriental despotism beyond anything seen in the Middle Ages. In place of temporal power, dependent in theory upon moral sanctions, he instituted unfettered autocracy. The rights of the Church and nobles in Sicily were swept away; Frederick claimed to be the head of Church and State. Shocked at his impiety and yet admiring his audacity, his contemporaries called him *Stupor Mundi*, the Wonder of the World. His ideas of political authority, substituting reason for faith, and aesthetic values for moral doctrines, secular omnipotence for ecclesiastical and religious control, naturally involved him in bitter conflict with the pope.

During the reign of Frederick II a new menace loomed over Europe from the East. The Mongol Tartars, under Jenghiz Khan (1162-1227), had set up a mighty dominion from the Tigris to the Pacific. In 1240 his successor's hosts swept through south Russia, wiped out its embryo civilization, and reached the confines of the Empire.

JENGHIZ KHAN, the Mongol world conqueror.

Then the unknown menace passed at a report of the death of the Great Khan; the Tartar hosts rolled away again as suddenly as they had come. Neither Empire nor Papacy had struck a blow to defend Europe. For two hundred years Russia was subject to Mongol overlordship.

LESSON 13

The Growth of Monarchy in Medieval Europe

The death of Frederick II left his son Conrad fighting in Germany against a rival claimant to the title of king of the Romans. Conrad died in 1254, leaving his half-brother Manfred to defend the claims of his infant son Conradin in Sicily and Germany. Frederick's successors shared his antagonism to papal authority, but lacked his genius and constructive policy.

CHARLES OF ANJOU, brother of Louis IX of France. Charles became king of Naples and Sicily in 1266.

In 1265 came the final phase of the struggle. The pope called from over the Alps a French prince, Charles of Anjou, brother of Louis IX, who led an army against Manfred. The Pope bestowed the crowns of the Sicilies and Naples on Charles. Manfred was killed; Conradin made a final effort, but was defeated, captured and beheaded by Charles in 1268. The house of Hohenstaufen was thus extinguished, and the imperial power collapsed. There was a period with no emperor; in 1273 the princes who formed the electoral body chose Rudolf of Hapsburg to succeed to the imperial dignity, being satisfied that his dominions were not large enough to enable him to be more than a figurehead. Rudolf was much more than that, but the empire had lost and never regained its place of unquestioned dominance in Europe. The balance of power shifted; general leadership of Europe passed to the western states. France and England were already beginning to apply Frederick's ideas of absolutism to their affairs.

Louis IX of France died in 1270; in 1272 Edward I of England succeeded his father, the weak Henry III. If Frederick II was the most brilliant prince of his time, Louis was the most admirable. His greatness, however, is to be measured rather by the influence of his character than by successful statesmanship. During his reign, Provence, technically within the empire, became in effect French through the marriage of Charles of Anjou and Naples to its heiress. Twice Louis attempted to revive the Crusading ideal which Frederick II had sought to twist to his own ends. In the first attempt he was disastrously defeated ; in the course of the second he died.

This was the last serious Crusade. Frederick's kingdom of Jerusalem had fallen under the sway of the Mameluke lords of Egypt, who had shattered the advance of the Mongol power westward ; and Edward of England, not yet king, who took command of the expedition on Louis' death, found the position hopeless. The Christian foothold in Asia was confined to a few small coastal states. Cyprus was in the possession of the Lusignans ; and Rhodes, held by the Knights Hospitallers, was still to remain for a long time the great naval outpost of Christendom. The Latin empire at Constantinople guttered out finally when Michael Palaeologus captured the city in 1261 and one more Greek imperial dynasty was set up; but its power within the peninsula was very slight, and western Europe paid little heed to it.

Rudolf of Hapsburg, lord only of some portion of Swabia, belied the judgement of the princes who elected him; he raised the house of Hapsburg to a leading position, which enabled him actually to make the imperial authority felt. This he achieved by recovering and appropriating the eastern border provinces —Austria or the East Marches—of which Ottocar, king of Bohemia, had possessed himself during the interregnum. The pressure of the Bohemian war forced him, however, to conciliate the Papacy by acknowledging the Pope's nominee and "vassal," Charles, Count of Anjou, as king of Naples and Sicily.

PHILIP THE FAIR, pictured on this seal, developed a powerful centralised administrative system in France. With Edward I of England he defied the Pope.

RUDOLF I OF HAPSBURG (1218–91). Head of the Hapsburg family, he secured for himself Austria and the headship of Germany. This equestrian portrait on the façade of Strasbourg cathedral dates from the year of his death.

On Rudolf's death, in 1291, the princes elected not his son Albert but another minor noble, Adolf of Nassau, for the reason that dictated their choice of Rudolf. They were too strong for him; but on Adolf's death Albert of Hapsburg secured election, and continued to strengthen his position till he was assassinated in 1308.

The island of Sicily detested its foreign monarch and the Frenchmen whom he set over them. In 1282 there was an unpremeditated rising and massacre of the French in Palermo, the ghastly event known as the Sicilian Vespers. The whole island was immediately in arms, and offered the Sicilian crown to the dead Manfred's son-in-law, Peter of Aragon, who accepted it. The island was made almost secure by Peter's powerful fleet. Charles and Peter died in 1285, but the conflict was continued by their sons until, in 1302, a composition was reached under which Naples went to Charles II of Anjou and the island kingdom of Sicily to Frederick, younger brother of King James of Aragon.

Philip IV of France

Louis IX left France enjoying a prestige resulting not only from his personality but also from the centralised administrative system he had inherited from his father and grandfather. His son was undistinguished ; but his grandson, Philip IV, the Fair, was a ruler of the same type as Philip II. He reigned from 1285 to 1314, and although he lacked the brilliant abilities of his ancestor he pursued the same policy with a like freedom from scruple, and his administrative developments left a permanent mark upon French institutions.

In summoning the States General, Philip IV did not set up a political force such as the parliament which Edward I was at the same time establishing in England. But he created the council of lawyers, called the Parlement of Paris, which, though not a parliament in the English sense, was a body able on several occasions in French history to exercise a decisive political influence. His trickery in reverting to the traditional methods of absorbing vassal fiefs into crown lands brought him into collision—from which in the end he reaped no advantage—with Edward, though one issue of it was the inauguration of a Franco-Scottish alliance. Similarly, his ambitions were foiled in Flanders, mainly through the crushing defeat of the French chivalry by the burgher infantry at Courtrai in 1302.

Decline of Papal Prestige

In foreign affairs the great feature of the reign of Philip IV was a conflict with the Papacy. Weakened by the conflict with Frederick II, also by the subsequent downfall of the empire which removed the possibility of a return to better relations with it, the Papacy had played a small part in the troubles which followed. Except in the brief reign of Gregory X (1271–76), who in happier circumstances and given more time might have gone far to restore its moral prestige, the Papacy was occupied with internecine rivalry until the election of Boniface VIII (1294–1303); he was a political genius, yet he failed to realize that his ideas belonged to the past.

Hildebrand (Gregory VII) had promulgated the theory that subordinated the nations to the Papacy; Innocent III had carried the subordination into practice. Boniface tried to do so again; he intervened with an offer of arbitration between Philip of France and Edward of England, which was declined by both. He forbade the clergy in both countries to pay taxes without his authority, but both kings compelled their clergy to submit to their demands, and Philip cut off contributions to the Papal exchequer. Boniface threatened him with an interdict, a weapon blunted by centuries of use.

BONIFACE VIII (c. 1230–1303). Elected pope in 1294, he insisted on the temporal supremacy of the papacy and so came into conflict with rulers backed by the rising spirit of nationalism. This fresco by Giotto is in the Lateran at Rome.

Edward I and Philip IV in different ways expressed nationalistic determination, and did not intend for one moment to admit the Pope's claim to supremacy. Philip finally dispatched to Anagni, where Boniface was then residing, troops who seized his person, using such violence that his death ensued (1303)—and with Boniface perished the Hildebrandine ideal. Two years later Philip secured the election of a nominee of his own, Clement V, who found his position at Rome untenable and removed the papal court to Avignon, where it remained, in effect, under French domination.

LESSON 14

Western Europe in the 14th Century

THE 13th century was the great medieval age. The zenith of medieval papal power was the reign of Innocent III. The supreme medieval expression in art took the shapes of the Gothic cathedrals. The flower of medieval Christianity blossomed in St. Francis of Assisi. It was the century of Dante and Giotto, of Roger Bacon, of Thomas Aquinas, and Duns Scotus, of Simon de Montfort and Bishop Grosseteste in England, of St. Louis in France, and of the emperor Frederick II.

The 14th century displays no such dominant figures. Intellectually exciting, morally decadent, it was an age of pageantry, glitter, and romance, when war was the game played by the few at the expense of the many; it was the age of the Black Death (1348) and of peasant revolts; and it contained the beginning of Protestantism fostered by John Wycliffe (*c.* 1320–84).

When Clement V went to Avignon in 1309, Philip IV was still reigning in France; the feeble Edward II had just succeeded Edward I in England; Robert Bruce was gradually recovering the Scottish Lowlands from the English garrisons planted there by Edward I; and

Henry VII, count of Luxemburg, had succeeded Albert I as emperor. Henry died in 1313, and the electors, ignoring his young son, divided their votes between two rivals, Frederick of Hapsburg and Lewis of Bavaria, who embarked on a nine years contest for the imperial crown. The Aragonese dynasty was established in Sicily; and in 1309 Robert of Anjou (1275–1343) succeeded to the throne of Naples, while his nephew, Charles Robert, became king of Hungary.

Suppression of the Templars

Almost the last act of Philip IV before his death in 1314 was directed towards the suppression of the military-religious order of the Knights Templars, who, together with the Hospitallers and Teutonic Knights, were in fact regiments of the Pope. They owed service only to Rome, and refused to pay taxes or acknowledge any king. While the Crusades lasted the Templars were tolerated; when the Crusades ended they were found intolerable. The Hospitallers were holding Rhodes, the Teutonic Knights were fighting the heathen Letts; but the Templars, with their enormous wealth, had no further task to perform. Apart from their anxiety to inherit its wealth, Philip of France and Edward of England had need to abolish this great military force before it was organized in defence of the Papacy.

Ironically, the suppression of the Templars was wrung from the Pope himself. Clement V was forced to condemn an order whose greatest crime was unswerving fidelity to Rome. Members of the order were accused of heresies learnt in the East. The organization was suppressed with torture, burning and confiscation.

Three sons in succession followed Philip IV on the French throne, while their sister Isabella was the wife of Edward II of England, whom she finally had deposed and murdered, nominally in favour of her young son Edward III. The last brother died in 1328, and with his death direct male succession from Hugh Capet was broken. The Paris Parlement pronounced that by French law the heir was Philip of Valois, son of Philip IV's brother, though Isabella put in a claim on behalf of her son.

HENRY VII (c. 1270–1313). French in speech and sympathies, he was elected German king in 1308. Three years later he went to Italy, where the Florentine poet and politician Dante had great hopes that he would stabilize the situation. In 1312 Henry was crowned emperor, but he proved unequal to the task.

HOSPITALLER AND TEMPLAR. Hospitallers wore over their armour a black mantle bearing a white cross, Templars a white mantle with a red cross. About 1137 the Hospitallers were made into a military order like that of the Templars.

Start of Hundred Years War

Ten years later Edward revived that claim and began what became the Hundred Years' War, primarily to gain full sovereignty over his fiefs in Aquitaine, and also over Flanders.

The first stage of the Hundred Years War, from 1338 to 1377, established that heavy infantry, rightly handled, could (as at Courtrai and Bannockburn) hold their own against mail-clad cavalry, and could in fact annihilate that cavalry when supported by the deadly English long-bow. It also proved the value to England of a fleet which could dominate the Channel. The capture of Calais (1347) gave England a permanent gateway into France and Europe.

The war enabled Edward and his son the Black Prince to perform astonishing feats of arms, as at Crecy (1346); it also proved the futility of victories with no more than a raiding strategy behind them. It retarded the political development of France, and left the Plantagenets with a weaker hold on their French possessions than when the war began. After the battle of Poitiers, in 1356, Charles V (1337–80) became the real ruler of France, his father John II having been taken prisoner to England. Charles actually succeeded, and was crowned at Rheims, in 1364.

CAVALRY AT POITIERS. An attack by the French mounted vanguard at Poitiers in 1356 was repelled with heavy losses by the English archers. The Black Prince's cavalry then charged the front and flank of the French and routed them. This illustration is from a 14th-century French MS.

The European situation as a whole was affected only so far as the Anglo-French war restrained French intervention elsewhere. To the east the Mongol or Tartar flood had ebbed almost of its own accord. The empire of the Seljuk Turks had been broken up in 1258 by the Mongols under Hulagu, grandson of Jenghiz Khan; their menace to Europe was renewed by the Ottoman Turks, named after their leader Othman, early in the 14th century.

Rise of Ottoman Power

Othman died in 1326, and under Orkhan the Ottoman power advanced rapidly in Asia Minor. In 1330 Orkhan captured Nicaea, and within a few years all that remained in Asia to Andronicus III, emperor of the East (1296–1341), was a strip of coast. Orkhan's successor, Murad I, captured Adrianople, which remained the Turkish capital in Europe till the fall of Constantinople in 1453.

The Slavonic Serbian power, which had increased under Stephen Dusan (1331–55), fell away after his death; and the Turk absorbed the Balkan peninsula piecemeal. Venetian and Genoese fleets, intent on commercial rivalry, fought each other in the eastern Mediterranean, and the apathy of Latin Christendom left the eastern Orthodox empire to take care of itself.

In 1322 Lewis of Bavaria took his Hapsburg rival prisoner; Pope John XXII at Avignon seized the opportunity once more to assert the papal claim to decide who should be emperor. Lewis rejected the claim; the order of the Franciscans supported Lewis, the rival order of the Dominicans supported the Pope, the Guelph and Ghibelline factions in Italy were similarly opposed. Lewis irritated his German supporters by his greed, alienated clerical sentiments by usurping clerical functions, and thus enabled the Pope to procure his formal but not his effective deposition. Charles of Luxemburg and Bohemia was elected king of the Romans;

EDWARD III AND PHILIP VI. With the death of Philip IV's youngest son, Charles IV, in 1328, the senior male line of the Capets became extinct; by a decision of the French peers the succession was given to Philip of Valois. Edward III, as son of Philip IV's daughter Isabella, disputed this decision but ultimately consented to do homage to Philip VI for his possessions in Guienne. The kings are shown here greeting each other, in a picture from a 14th-century French chronicle.

and on the death of Lewis, in 1347, Charles IV secured the imperial crown.

Hungary was vigorously developed under its Angevin kings, Charles Robert and Lewis the Great ; the latter died in 1382, having acquired, by arrangement, the crown of Poland. For Bohemia, Charles IV (1316–78) was an entirely admirable king ; as emperor, he promulgated the decree of 1356, called the Golden Bull, which regulated the electoral system governing the imperial succession. It established as Electors the king of Bohemia, three archbishops, and the rulers of Brandenburg, the Palatinate and Saxony. The dukes of Bavaria and Austria were excluded.

Individually and collectively the Electors wielded a power effective against the development of a strong central government. Charles, however, procured during his own lifetime the election of his incompetent elder son Wenzel as king of the Romans ; the younger, Sigismund, married the daughter and heiress of Lewis of Hungary. Charles IV died in 1378, the year when the Great Schism was opened by the election of rival popes, Urban VI at Rome and the anti-pope Clement VII at Avignon.

LESSON 15

The Era of the Great Schism

When Pope Gregory XI died in 1378 the Anglo-French war had been in suspense since a treaty in 1375 ; the king of England was Richard II ; in France Charles V, whose rule, first as regent and then as king, had done much for the country during the preceding 30 years, died in 1380. His successor, Charles VI, was imbecile at best, and insane for long periods. The royal dukes, uncles, brothers, or cousins of the king, were divided into warring factions, Burgundians and Orleanists—or, as they were later called, Armagnacs. In Germany Wenzel, king of Bohemia and of the Romans, was a drunkard who lacked the vigour or intelligence to prevent a civil war—during which central government in his dominions virtually ceased. His brother, Sigismund, had a prolonged struggle to secure his wife and, with her, the crown of Hungary. Her sister Hedwig married Jagellon, the duke of heathen Lithuania, who adopted Christianity himself, imposed it on the Letts, and founded the Jagellon dynasty of Poland.

GIAN GALEAZZO VISCONTI brought most of Lombardy under the despotism established by his family in Milan. In 1395 he persuaded the Emperor Wenzel to create him duke of Milan ; this relief on his tomb commemorates the occasion.

In Italy, Venice in 1380 finally won the struggle against Genoa for supremacy in the Mediterranean. Gian Galeazzo Visconti (1347–1402), tyrant of Milan, was rapidly mastering the other cities of the north ; in 1395 he obtained from Wenzel the title of independent duke of Milan. In the west the little kingdom of Portugal escaped possible absorption in the greater Castile by the decisive victory of Aljubarotta (1385). Peace was secured when Henry III of Castile and John I of Portugal married daughters of John of Gaunt, whose son deposed Richard II and became Henry IV of England (1399). The long reign of John of Portugal (1385–1433) was notable for the beginnings of Portuguese activities in maritime exploration.

Asiatic Conquests of Tamerlane

Throughout the last quarter of the 14th century the Ottoman menace increased under Murad and his son Bajazet, who succeeded him in 1389. Greek dominion amounted to very little outside the walls of Constantinople. The emperor John V, failing to obtain aid from the west, acknowledged himself the vassal of the Ottoman. The Slavonic states formed a league of defence, but a crushing defeat was inflicted on them at Kossovo (1389) ; annexation of Bulgaria forced Sigismund of Hungary to take the field, but he in turn met with an overwhelming defeat, from which he barely escaped with his life, at Nicopolis (1396). Bajazet advanced against Constantinople itself, from the east :

his power was broken and he himself was taken prisoner, at the battle of Angora (1402), by Timur "the lame," or Tamerlane (1336–1405). Tamerlane was a Turk who had in 1369, after a career of conquest, seized the throne of Samarkand. His previous conquests included Georgia, most of Persia, the Caucasian states, and large portions of India.

In time of peace Timur ruled wisely, patronising the arts and learning and promoting social welfare. In time of war he slaughtered incredible numbers of captives. He was a zealous Mahomedan. Bajazet died in captivity in 1403, and for ten years his sons fought for the succession; Tamerlane, instead of pouring his hosts into Europe, turned back to the east, intending to conquer China, a project frustrated by his death, in 1405, in his 70th year. His empire vanished with his death; nothing but his lust for conquest had held it together.

TAMERLANE (1336–1405). This Tartar king of Samarkand after conquering Persia and northern India subjugated Asia Minor.

The West was thus released from immediate Turkish pressure. Wenzel, though not unpopular in Bohemia, could not control Germany and resigned in favour of his brother Sigismund, king of Hungary. In 1410 an imperial election elevated their cousin Jobst instead. Jobst died before he could be crowned, and Sigismund became emperor.

An attempt to end the "captivity" of the Pope at Avignon involved the Papacy in another disaster, the Great Schism. Pope John, the chosen of the Council of Pisa, appealed to Sigismund for support, promising to call a General Council whose authority should be accepted as conclusive. On that understanding Sigismund gave him support, and the Council of Constance was duly assembled (1414).

Though the official business of that Council was the termination of the scandal of a divided Papacy—at Avignon and in Rome—and of the schism of Christendom, the underlying need was that of spiritual and moral reformation within the ecclesiastical body, without which the authority of the Church could never be restored. Sigismund intended also to establish the old doctrine that the emperor was the secular head, as the Pope was the spiritual head, of Christendom; the reforming party among the Churchmen had no thought of doctrinal changes, being intent on administrative reforms along nationalist lines. The Council deposed three rival popes—Gregory XII at Rome, Benedict XIII at Avignon, and John XXIII—and set in their place Martin V, a man of character and distinction. Arrangements were made for the meeting of a succession of Councils to deal with questions of reform, in spite of Martin's uncompromising assertion of the Pope's own supremacy; but the Council itself provoked a situation far beyond its intention. Sigismund was responsible for the way it came about.

Martyrdom of John Huss

The University of Prague had risen to the highest rank under the care of Charles IV; latterly it had in effect excluded its German elements and was fervently nationalist. Its doctors, headed by John Huss (*c.* 1373–1415), had gradually absorbed and disseminated the teachings of the English reformer John Wycliffe (*c.* 1320–84), which cut at the roots of formal ecclesiastical authority and, from the conservative point of view, of civil authority also. Orthodox ecclesiastical and political authorities denounced Huss, but the Bohemians supported him. He could appear at Constance only at great peril; Sigismund urged his attendance, under his own guarantee of security. Huss came, was charged with heresy, condemned, and sent to the stake. Sigismund had withdrawn the protection, persuaded to that act of treachery by his ablest and most trusted adviser, Frederick of Hohenzollern, who became elector of Brandenburg three months before the sentence on Huss was carried out.

JOHN HUSS (c. 1373–1415). Priest and rector of Prague university, John Huss was summoned to Constance where, despite his safe-conduct, he was condemned for heresy and burnt at the stake.

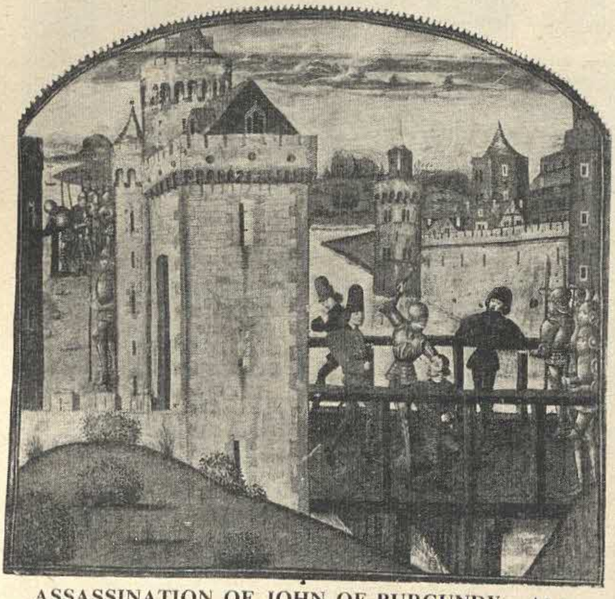
Sigismund's perfidy saved the Council from immediate disruption; the work on hand was completed before its dissolution in 1418. The judicial murder of Huss had given it solidarity; the Hussite doctrines were heresy as poisonous to lay rulers as to Churchmen. Outside Bohemia it did not even discredit Sigismund, but in Bohemia it kindled an unforeseen conflagration.

SIGISMUND, king of Hungary, was elected German king in 1410 and became de facto emperor. A tragic blot on his character is his betrayal of Huss.

Renewal of the War

The Council of Constance was in session when in 1415 the Hundred Years War was renewed between France and England. The ambition of Henry V was encouraged by civil war in France and the imbecility of Charles VI. In the first campaign Harfleur was captured and Agincourt fought and won ; Henry then set about the conquest of Normandy. The assassination of John the Fearless of Burgundy at a meeting between him and the dauphin, by one of the latter's escort, drove John's son, Philip the Good, to alliance with the English, and the treaty of Troyes disinherited the French king's only surviving son in favour of the English king, who married his daughter. Both kings died in 1422 ; the unconquered two-thirds of France acknowledged the Dauphin Charles, not the baby Henry VI.

For a time the English made slow progress, till the tide was checked by Joan of Arc. She was taken prisoner and burnt as a heretic in 1431. Then a breach developed between England and Burgundy; the alliance was dissolved in 1435 ; and in 1453 the English had lost everything in France except Calais, and the Hundred Years War was over. The French kings could again turn to the task of constructing a strong central government, a task complicated by the expansion of Burgundy under its Valois dukes.



ASSASSINATION OF JOHN OF BURGUNDY. At a meeting on the Bridge of Montereau, September 10, 1419, to effect reconciliation with the dauphin (later Charles VII), John of Burgundy was killed by one of Charles's escort. This representation is from a nearly contemporary miniature.

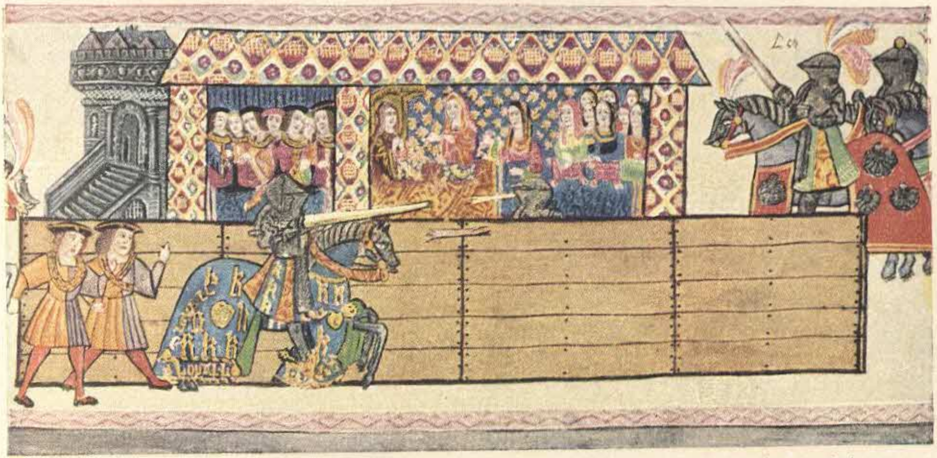
The Netherlands, over which by their marriages these dukes held sovereignty, possessed great trading cities and were very wealthy. The second duke, Philip, though still a feudatory of France, had become in respect of Burgundy practically independent. He had the best filled treasury in Europe, and stood to the French crown in a relation very similar to that of the Angevin kings of England in the 12th century.

Hussite Wars

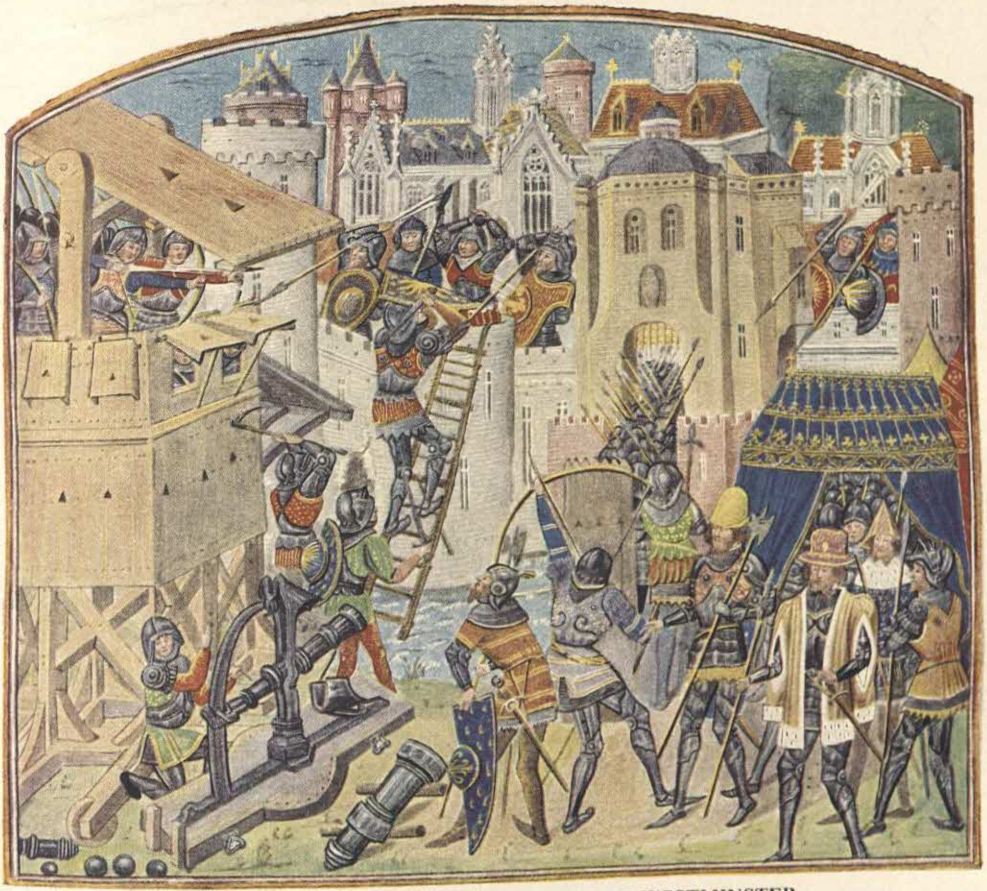
After the betrayal and martyrdom of John Huss, Bohemia remained stubbornly and angrily Hussite. Wenzel's death in 1419 left Sigismund sole king of the Romans, and he was called emperor, though he was not actually crowned till 13 years later. Bohemia, however, declined to submit to him. The reformers in 1420 issued their demands, the "Four Articles of Prague." In the same year Pope Martin, with the emperor's concurrence, proclaimed a crusade against them. A German army was routed by the brilliant Hussite captain Zizka.

The crown of Bohemia was offered to Ladislaus of Poland, who refused it, thereby missing the chance to unite two Slav states against the threat of German domination. Two more crusades against the Hussites failed ignominiously. In 1431, when he had summoned another General Council to meet at Basel (finally dissolved in 1449), Martin died and was succeeded as Pope by Eugenius IV. The Council invited the Hussites to send delegates to Basel, and a compromise, the *Compactata*, was arrived at which satisfied the Bohemians.

In 1437 Sigismund died, and the electors chose as his successor the Hapsburg Albert of Austria, son-



Jousting, or medieval conventionalised combat between two knights, was usually carried on as part of a tournament. Here Henry VIII jousts at Westminster, London, in honour of the birth of a son to his first queen, Catherine of Aragon, who watches from a canopied couch.
Royal College of Arms, Westminster Roll



A MEDIEVAL SIEGE; AND JOUSTING AT WESTMINSTER

Illustrative of the methods of siege war in the period of the Hundred Years War, this picture is from a late 15th-century MS. of Froissart's "Chroniques d'Angleterre."
British Museum, Royal MSS.

in-law of Sigismund, whom he also succeeded as king of Bohemia and Hungary. Albert died in 1439 (his son, Ladislaus Postumus, being not yet born); another Hapsburg, Frederick of Styria, was elected king of the Romans; after him, the imperial succession became hereditary in the house of Hapsburg. When the baby Ladislaus was born, Bohemia and Austria recognized him; the Hungarians, however, offered their kingdom to Ladislaus of Poland. When he was killed at Varna, in 1444, Hungary reverted to the child Ladislaus.

LESSON 16

The Turkish Menace in Europe

THE Ottoman advance had been suspended by Tamerlane's overthrow of Bajazet at Angora in 1402. Tamerlane's retirement left Bajazet's sons fighting for the succession. One son, Mohammed I, secured the sole sultanate, but was too much occupied in Asia to make trouble in Europe. But in 1427 his successor Murad II was confrónted by a coalition of Hungary and Poland; their armies were led to notable successes by the Hungarian hero Janos (John) Corvinus Hunyadi, who extorted from Murad the very favourable treaty of Szegedin (1444). But the Christians, urged on by Pope Eugenius, invaded Bulgaria, and they met with a crushing defeat at Varna, where Ladislaus of Poland and Hungary was killed. Hunyadi escaped, but all that had been gained by the treaty was now lost.

The eastern emperor John VII had kept the peace throughout his feeble reign, ignored by Murad, though he made a despairing effort to get aid from the West by agreeing, at the Council of Florence in 1440, to unification of the Eastern and Western Churches. On his return to Constantinople his subjects refused to honour the agreement. In 1448 John was succeeded by his brother Constantine XII, last of the Greek emperors—a brave soldier who, knowing that the end of the empire was at hand, determined to fight to the last. The only foreign help he had was that of Venetian, Genoese, or other shipmen. By confirming his brother's agreement he alienated the majority of his own subjects and procured no aid from the West.

Fall of Constantinople

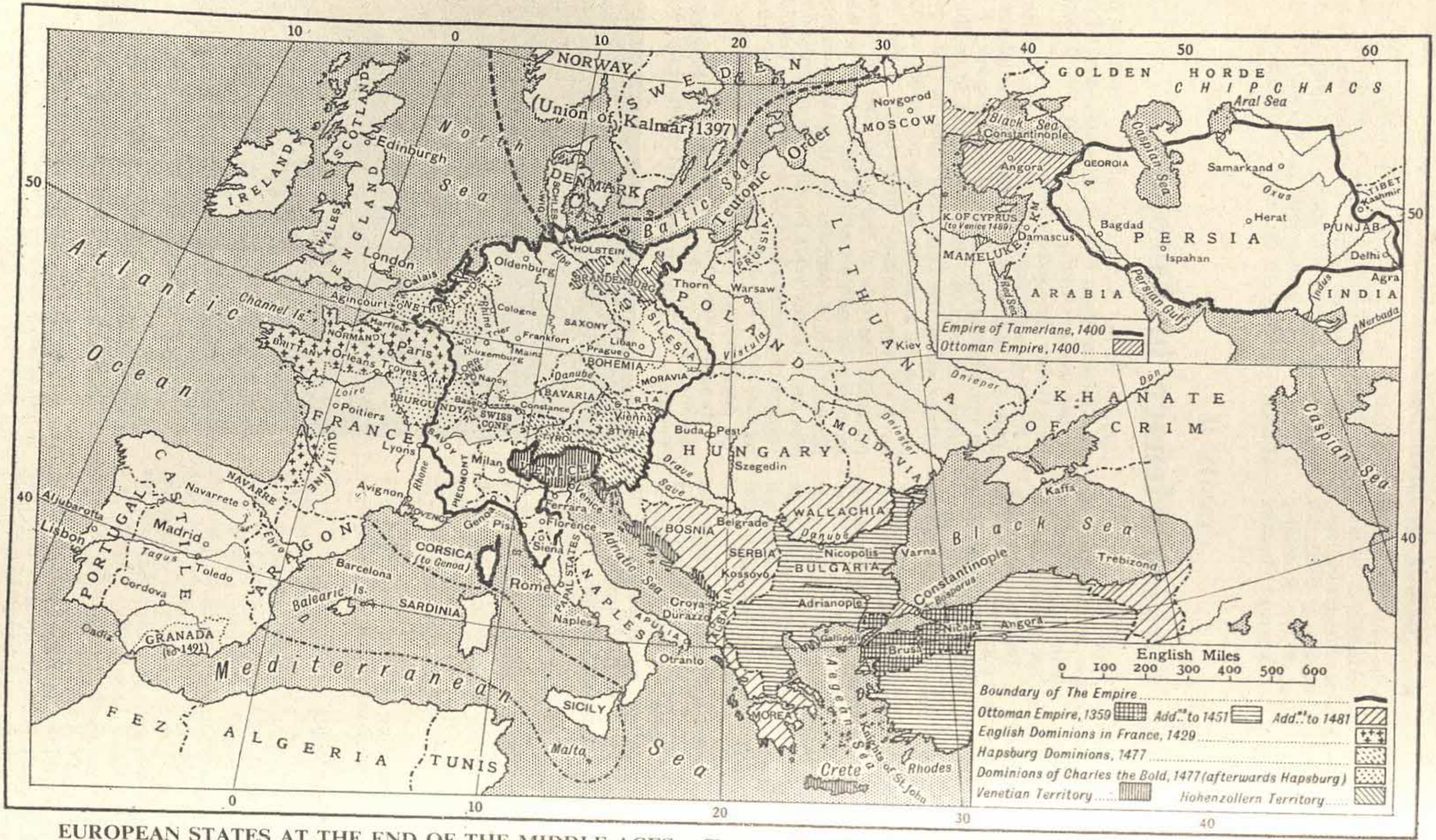
In 1451 Mohammed II succeeded Murad II. Throughout 1452 he prepared to besiege Constantinople. In the following spring the siege opened. A Genoese squadron forced an entry, bringing supplies to the scanty garrison. Then the toils closed on the doomed city. On May 29 the walls were breached; in swarms the Turks poured through and overwhelmed the garrison of not more than 10,000. Constantine was slain fighting, and the Crescent floated over the cathedral of St. Sophia.

In the years following the capture of Constantinople Mohammed consolidated his Asiatic and European empire and completed his subjugation of the Balkan peninsula. In spite of the efforts of Pope Pius II, no steps were taken by the western monarchs to help the Balkan Slavs before they were conquered.

In Albania the national hero George Castriot (1403–67), universally known as Scanderbeg (in complimentary reference to Alexander the Great, i.e. Iskander Bey), remained invincible. Carried off by the Turks as a child, he had early attracted the attention of Murad, under whom he had won military distinction. Later he preferred the role of patriot to that of commander in the sultan's service, and in 1443 he had deserted with a company of Albanian soldiers. For some twenty years he valiantly inspired and successfully headed resistance against Turkish aggression. The collapse of his country after his death proved the value of his leadership.

Hungary stood as the bulwark of the West, keeping hold on the key-fortress of Belgrade. Though the Hungarian patriot Hunyadi was

MOHAMMED II (1430–81). Born at Adrianople, he succeeded his father, Murad II, in 1451. In 1453 he led an army of 150,000 men against Constantinople and captured it after a siege of 53 days.



EUROPEAN STATES AT THE END OF THE MIDDLE AGES. Changes effected in Europe between the 14th century and the birth of the Renaissance in the 15th century are shown. Notable points are the growing power of Hapsburgs and Hohenzollerns in the Empire, fluctuation of English dominion in France, recession of Saracen power in Spain, development of the Ottoman Empire and extension of Venetian territories. In the East the most important shift of power resulted from the meteoric career of Tamerlane.

MATTHIAS CORVINUS (1443–90). Son of Janos Hunyadi, he was elected king of Hungary in 1458.

defeated at Kossovo (1448) the Turks had not followed up that victory, being intent on their attack on Constantinople. After the fall of the city Hunyadi realized that the best he could do was to hold the line of the Danube; he therefore put the fortress of Belgrade in a state of defence.

Mohammed arrived before Belgrade with 300,000 men and the most formidable siege artillery of the age. Hunyadi relieved the town, and all the sultan's efforts to carry the fortress by storm failed; having lost 40,000 men he retreated (1456), leaving behind much of his artillery. Soon after this great service to Hungary and to Europe Hunyadi died. His son, Matthias Corvinus (1443–90), was elected king in 1458.

Famed for the splendour of his embassies, Matthias was chiefly concerned with revising the laws, promoting literature, the arts and education, and supporting the general interests of the people against oppression by the nobles. In 1465 he founded the university of Pressburg. He introduced printing into Hungary, which through his efforts was able to participate in the Renaissance.

Turkey's Inroads on Italy

Venice sustained a 15 years' struggle with the Turks by sea, though in the end she was forced to make terms with Mohammed. Only when, in 1480, Mohammed seized Otranto (Tarentum) did the West awake to danger; but Mohammed died in the following year, and was succeeded by his feeble son Bajazet. Otranto was evacuated, and the Ottoman advance was postponed for a generation; no attempt was made to expel the Turks from eastern Europe, though in the West Islam was about to be evicted from Spain as a result of the union of the kingdoms of Castile and Aragon.

Ferdinand and Isabella

In 1469 Ferdinand, crown prince of Aragon, married Isabella of Castile, who a year before had been officially recognized as heiress to her brother, Henry IV. She succeeded him on the throne in 1474; Ferdinand succeeded to the throne of Aragon and Sicily in 1479. Ferdinand's succession to Sicily did not include Naples, where in 1442 Alfonso V of Aragon had succeeded the last Angevin ruler, Joanna II. Alfonso was himself succeeded in Naples, but not in Aragon, by his illegitimate son Ferrante, whose title might at any time be challenged either by his legitimate cousin Ferdinand of Aragon (whose claim was made good in 1504) or by the head of the house of Anjou.

Leading Families of Milan and Florence

In Italy, Milan became a bone of contention, the French house of Orleans having a claim there by descent from the daughter of Gian Galeazzo Visconti, the first duke. On the death of the last Visconti his place had been taken after a short interval, in 1450, by Francesco Sforza, who rose to be a dominant figure in medieval Italy. In Florence the Medici family had established a personal ascendancy, confirmed when Lorenzo the Magnificent became head of the state in 1469 at the age of 21. A many-sided ruler, this crafty and able politician towered over his contemporaries by reason of personality. He established the Medici family among the princely houses of Europe, reigning as the first citizen of the Florentine republic. He was the chief patron of the artists of the Renaissance.

The close alliance between Matthias Corvinus and George Podiebrad, the elected king of Bohemia, which had at first seemed probable,

LORENZO DE' MEDICI (1448–92). Succeeding to the headship of the Florentine republic in 1469, he raised Florence to the pinnacle of its greatness. A scholar and poet, he welcomed to his court the leading artists and literary men.

would have been an invaluable defence against Ottoman aggression, but they were divided by religious antagonism, Podiebrad being a Hussite; and on his death in 1471 Bohemia elected Ladislaus of Poland to the crown which Matthias had hoped to acquire. The three crowns of Bohemia, Hungary, and Poland were temporarily united by the election of Ladislaus in Hungary on the death of Matthias in 1490, after he had added to his kingdom extensive Hapsburg territories, later recovered from Ladislaus by Frederick III's son Maximilian.

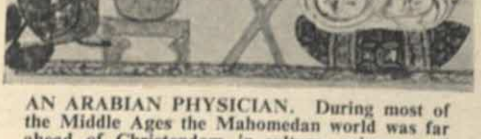
The Council of Constance had removed a great scandal, but had not restored the spiritual authority of the Church or dethroned the papacy in favour of conciliar supremacy. In effect, Eugenius had defeated the Council of Basel; Pius II (1405–64) was the only Pope of the age inspired by anything resembling the ideals of the great popes of old. With the election of Sixtus IV in 1471 the real degradation of the Papacy set in, though its nadir was not reached till the accession of Rodrigo Borgia as Alexander VI in 1492. Each pope had pursued the fatal policy of aiming first at political ascendancy; it was reserved to Sixtus to use his sacred office as a means to the advancement of his own kinsmen.

LESSON 17

A Glance at the Medieval East

THIS account of medieval history is not complete without a glance at the East—that great portion of Asia which lay outside the ken of the peoples of Europe from the days of Trajan to the close of the 15th century: India, China, and Japan; and central Asia, occupied from time immemorial by nomadic or semi-nomadic hordes of Mongols, Turks, Huns, Tartars—none of whom ever created a national civilization.

In the Ancient History Course, Lesson 24, reference is made to the Gupta empire in northern India and to the incursion of the White Huns. In the 7th century a monarch named Harsha restored order throughout northern India. Islam had now entered on its conquering career; conflict between Mahomedans and Hindus begins with the long series of raids conducted by Mahmud of Ghazni during the first 30 years of the 11th century, when Persia and Afghanistan were provinces of the Baghdad caliphate, though Afghanistan was virtually an independent kingdom under a Turkish dynasty. Mahmud was a plunderer rather than a champion of the Moslem faith. His attacks were fiercest against the descendants of the Arabs in Sindh, who opposed him; while the Hindus of the Punjab, the only Indian province which he definitely annexed to the Ghazni sultanate, were usually left to observe their religious rites in peace. Nevertheless, the Mahomedan invasions introduced for the first time into India a permanently alien element, which could not be absorbed. To the monotheistic Moslem, Hinduism was an abomination of polytheism and idolatry.



AN ARABIAN PHYSICIAN. During most of the Middle Ages the Mahomedan world was far ahead of Christendom in culture, science, and medical knowledge. European doctors learnt much from Latin translations of Arabian books.

DELHI TOMB OF A MOSLEM RULER. Ghiyas ud-Din (d. 1325), founder of the Tughlak dynasty, was buried in this exquisitely proportioned tomb of red sandstone with white marble courses.

Moslem Conquest of Northern India

Mahomedan conquest of northern India began about a century and a half after Mahmud's death, with the invasions of Mohammed of Ghor (died 1206); he advanced victoriously as far as Bengal, which never again escaped the grip of the Moslem sultans. The armies of the Indian princes were no match in organization, discipline, or armament for the professional fighting men, mainly Turks or Afghans.

Mohammed of Ghor subdued much of northern India himself, but the great part of the conquest, including the taking of Delhi, which he made his capital, was performed by his slave Kutb-ud-Din. He, when his master was slain in 1206 leaving no heir, became the real founder of Moslem rule in India and of the dynasty of the Slave Kings, which lasted till 1294, when its place was taken by the Khilji dynasty.

Ala-ud-Din Khilji distinguished himself by enunciating the general principle that Hindus were to be allowed nothing more than a bare subsistence. His armies ravaged the Deccan, and he conquered Rajputana and Madura. The Rajputs held their stronghold of Chitor until further resistance was obviously hopeless; then all the women gathered together to perish in a vast holocaust, and the men sallied forth to fight till all were killed.

FOUNDER OF JAPANESE DYNASTY. Tokugawa Iyeyasu obtained in 1600 the title of Shogun in recognition of his great military services. He founded the dynasty of rulers known as the Tokugawa Shogunate.

The succeeding Tughlak dynasty (1320–88), founded by Tughlak Shah, who built a new suburb to Delhi as his imperial residence and named it Tughlakabad, was continued by Mohammed, whose reign was an orgy of cruelties, and ended with Firoz Shah (1351–88), a better ruler than his predecessors, who strove to restore sound government. But the foundations of the empire were so sapped by Mohammed that the Moslem empire declined; 10 years after his death came the invasion of Tamerlane.

The Delhi empire, though not the Mahomedan domination, was already moribund when the century closed. Tamerlane turned aside from his advance to the overthrowing of Bajazet at Angora, to devastate the Punjab and upper Hindustan, sack Delhi, and indulge his predilection for miscellaneous slaughter. In the 15th century the empire disintegrated into a number of warring Mahomedan kingdoms; towards its close an Afghan dynasty was establishing itself at Delhi when the Europeans were on the point of making their first landing. But it was a new conqueror from beyond the mountains of the north-west, a descendant of the Mongol Jenghiz Khan, conqueror of central Asia in the 13th century, and the Turk Tamerlane, who, in the next century, was to re-create the Mahomedan empire.

Feudalism in Japan

Japan from time immemorial dwelt in isolation, in spite of recurrent descents upon Korea. In Japan, under the sacred imperial family of the Emperors, a sort of feudal system, the lordship of a land-owning military caste, was developed as in Europe in the early Middle Ages. In the 13th century a baronial leader assumed the imperial function, though not the title. This Shogun, or commander-in-chief, became the effective head of the state; and the government remained in the hands of the Shogunate, despite periodical attempts on the part of the emperors to recover control, until the 19th century. The other outstanding event of Japanese history in the Middle Ages was the repulse in 1265 and 1274 of invasions by the Mongol emperor of China, Kublai Khan—a repulse the equivalent in Japanese history of the Greek overthrow of the Persians at Marathon and Salamis.

In the early medieval period China appears to have enjoyed under the Tang dynasty what

MARCO POLO ON HIS TRAVELS. A Venetian noble, Marco Polo (c. 1254–1324) set out with his father and uncle for China in 1271. Travelling across Tartary and the Gobi desert, they arrived at Chandu, Kublai Khan's summer residence, in 1275. Marco Polo won the favour of the Great Khan and was employed by him on several missions.

KUBLAI KHAN AT LUNCH. This illustration from the "Livre des Merveilles," a MS. written about 1351, shows the Great Khan lunching in a kind of summer pavilion with his wife and sons.

was traditionally one of her "Golden Ages"—tempered by attacks of the Khitai Tartars, from whom Europeans derived the name of Cathay.

China under Kublai Khan

In the 13th century China was conquered by the successors of Jenghiz Khan, who gave her a famous ruler in that Kublai Khan (1214–94) who failed to extend his dominion over Japan. Unlike most Mongols he was a constructive statesman. His picture was left to us by the Venetian traveller, Marco Polo, who set out to visit China in 1271 and arrived at Kublai Khan's summer residence Chandu (the Xanadu of Coleridge's poem) in 1275, when the Mongol conquest of China had been completed. Kublai Khan's capital was at Cambaluc, which occupied much the same site as Peking. Polo gives graphic details of the emperor, his court, its feasts and festivals, the splendour of his palaces, gardens and pavilions, and of the most beautiful of his four empresses, the Great Consort Jamui Khatun, who exercised an amiable influence over Kublai.

KUBLAI KHAN (1214–94). Grandson of Jenghiz Khan, he became Grand Khan in 1259 and then conquered China.

The Mongol dynasty degenerated after the death of Kublai Khan and was overthrown by the Chinese patriot Hung Wu, monk, soldier, statesman, and reformer. After the latter's death, in 1399, the Ming dynasty which he founded lost its vigour but was still reigning at the close of the 15th century.

LESSON 18

Western Europe at the Close of the Middle Ages

During the 15th century the European political system based on feudalism was breaking up. Forces intellectual and religious operated against the rigidity and "communism" of the Middle Ages; individualism, nationalism, and humanism emerged to separate medieval from modern history. In England the breakdown of the Lancastrian monarchy after the death of Henry V brought about the collapse of the prestige he had won for her as a military power on the Continent, and culminated in the collapse of the Lancastrian monarchy itself, in the civil wars of the Roses. Henry VII (1457–1509) who was descended from an illegitimate branch of Lancaster, married the heiress of York, and was able to prevent the development of baronial domination, and to establish the supremacy of the crown for three generations of Tudors.

The great French nobles had always been more independent than the barons in England. The Hundred Years War itself had opened as a struggle between the French monarchy and its powerful feudatory England. Its renewal in the 15th century had been made practicable because Burgundy sided with the Plantagenet against the reigning Valois, and the Plantagenet was finally defeated because Burgundy reverted to French allegiance. The expulsion of the English enabled Charles VII and his ministers to carry out administrative reforms—notably the creation (1439) of a royal force under strict discipline and control of the crown, independent of feudal levies, and absorbing or suppressing the "free companies," which when not in fighting service had lived by threats and plunder. Philip of Burgundy was more concerned with his wealthy dominions outside France than with resisting the centralising process within France.

French "Princes of the Lilies"

The practice which arose in the 13th century of distributing among royal princes the fiefs which passed to the crown by lapse or forfeiture had been intended to strengthen the royal family against the old feudal baronage;

CHARLES VII, crowned at Rheims in 1429, owed his coronation to Joan of Arc.

but it had created a new nobility of "Princes of the Lilies," or blood royal, as jealous of their privileges as the other dukes and counts, and as resentful of any royal encroachment. The reforms of Charles VII set the Dauphin Louis at the head of the resistance of the "Princes," and Louis was driven to take refuge at the court of Burgundy; but when in 1461 he ascended the throne as Louis XI, he set himself to break the power of the "Princes of the Lilies." His young cousin, Charles the Bold of Burgundy, became their leader. In the long duel which followed, the crafty Louis provoked discord and broke up the combination of the Princes.

CHARLES THE BOLD (1433–77). Succeeding his father as duke of Burgundy in 1467, Charles spent his reign in warfare.

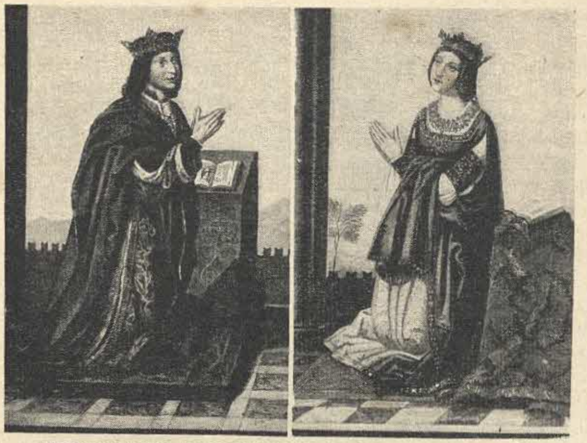
Charles aimed at the ambitious objective of reviving the old middle kingdom of Burgundy between the mouths of the Rhine and the Rhône. The intrigues of Louis undermined his schemes; but in the pursuit of them he set about development of his ambitions on the other side of the Rhine, laying claim to sovereignty over the Swiss confederation. The Switzers defied him, defeated him, and finally overthrew and killed him at the battle of Nancy in 1477. With his death his project perished. His daughter and heiress Mary was married in the same year to Maximilian, son and heir of the Hapsburg emperor Frederick III. The Burgundian dominions remained under her sovereignty, not that of her husband, and passed to their son Philip, and after him to his infant son Charles, who as Maximilian's grandson was also heir to the Hapsburg dominion, and through his own mother, Philip's wife, Joanna of Castile, to the crown of Spain. This aggregation of sovereignties in the hands of one prince, who also succeeded to the imperial crown, was not completed till Maximilian's death in 1519.

On the death of Charles the Bold, Louis tried in vain to claim the Burgundian succession, but he had to be satisfied with retaining the French duchy as well as Artois and Picardy; the Netherlands and the trans-Rhenish county remained with the duchess and continued to be known generally as Burgundy. The crown absorbed the French duchy, Champagne, and other major fiefs, Brittany alone retaining some of its old independence; by the employment of ministers who were not of the nobility but were creatures of his own Louis gathered into his own hands complete control of that administration. The regency for his infant son Charles VIII was conducted by his very capable elder daughter, Anne of Beaujeu; and there was no return to feudal disintegration. Later, the marriage of Charles to the young duchess of Brittany brought that fief, too, under royal control.

Frederick III of Hapsburg kept the imperial dignity from 1440 till his death in 1493; during his life he succeeded to the inheritance of his Hapsburg cousins, heretofore divided between different branches of the family. His son Maximilian secured Burgundy by his marriage to the daughter of Charles the Bold, and his own succession to the imperial throne by his election as king of the Romans in 1486. He at once set about recovering the territories of which his father had been deprived by Matthias (Corvinus) of Hungary.

In Spain a new age opened under Ferdinand and Isabella: the union of the crowns of

LOUIS XI OF FRANCE (1423–83). Succeeding his father, Charles VII, in 1461 he encouraged the middle class at the expense of the feudal nobility, averted the menace of an English invasion, and became the consolidator of modern France.



FERDINAND AND ISABELLA. Ferdinand V (1452–1516) succeeded his father as king of Aragon in 1479. His queen, Isabella (1451–1504), daughter of the king of Castile, succeeded to the Castilian throne in 1474. Two of the four Spanish kingdoms were thus united.

Castile and Aragon in 1479 enabled the two monarchs to support each other in their respective kingdoms; jealousy prevented their subjects from making common cause against the rulers, so that the crown was greatly strengthened in both. In the main, however, their subjects were with them—in the establishment of the Inquisition as an engine for the suppression of heresy, in the persecution of the Jews and Mahomedans; and in the war which destroyed the last relic of Moorish independence in the peninsula.

Momentous Voyages and Discoveries

Some six years before the conquest of Granada the Portuguese Bartholomew Diaz opened the ocean route to the East by rounding the Cape of Good Hope. And in the year of that conquest, 1492, the Genoese Christopher Columbus, in the service of the Spanish monarchs, voyaged across the Atlantic expecting to land on the shores of India; he found the West Indies instead. These discoveries produced during the Renaissance period a vast and sudden change in economic conditions. Next year the new Pope, Alexander VI—Rodrigo Borgia (1431–1503)—issued a bull bestowing all the lands which might be or had been discovered: upon Portugal those east, and upon Spain those west, of a line drawn down the Atlantic from north to south, the papal authority being as yet unchallenged.

In 1494 young Charles VIII of France invaded Italy to assert his claim as head of the historic house of Anjou to the crown of Naples. Here an account of the Middle Ages may suitably be closed, for these last events mark the starting-point of Modern History.

BOOK LIST

General. *Universal History of the World*, ed. Sir John Hammerton (Amalgamated Press); *Ancient Times*, J. H. Breasted (Ginn); *A History of the Ancient World*, M. I. Rostovtzeff (O.U.P.); *Cambridge Ancient History*, *Cambridge Medieval History* (C.U.P.); *History of Europe*, H. A. L. Fisher (Spottiswoode).

The Ancient World. *A History of the Ancient Egyptians*, J. H. Breasted (Murray); *History of Egypt*, Sir Flinders Petrie (Methuen); *Ancient History of the Near East*, H. R. Hall (Methuen); *The Sumerians*, C. L. Woolley (O.U.P.); *Ur of the Chaldees*, C. L. Woolley (Benn); *Civilisation of Babylonia and Assyria*, M. Jastrow (Lippincott); *History of Persia*, Sir Percy Sykes (Macmillan); *The Hittite Empire*, J. Garstang (Constable); *Minoans, Philistines and Greeks*, A. R. Burn (Kegan Paul); *Palace of Minos*, Sir Arthur Evans (Macmillan); *Homer and Mycenae*, M. P. Nilsson (Methuen).

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MODERN HISTORY

All history is one, but for the sake of convenience in presentation it is customary to divide it into three sections—ancient, medieval, and modern. The present Course begins in the second half of the 15th century—when the printing press was invented, Constantinople was conquered by the Turks, and the new world of America was discovered—and it continues down to 1955.

While much of medieval, like all ancient history, has to be pieced laboriously together from meagre records, modern history has for its basis such wealth of documents that only by strictest compression can the story of the world during the last 500 years be condensed within reasonable space. As outlined here it should enable the student to determine those eras to which he would care to give more detailed study.

ANCIENT AND MEDIEVAL HISTORY *is treated in this Volume ;* SOCIAL HISTORY *in Vol. 4 ;* BRITISH HISTORY *in Vol. 5 ; and the allied subject* POLITICS *also in Vol. 5.*

33 LESSONS

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LESSON 1

The Beginnings of the New Era

THE division of recorded time into ancient, medieval, and modern history is purely arbitrary : the story of mankind runs steadily down the centuries from before the earliest known era to the present day and, for all that is known to the contrary, will continue into future millenia even though the civilization of the 20th century pass into oblivion. But the division which scholars have made is convenient ; and the section of human history with which this course of lessons deals begins at the end of the 15th century.

The Renaissance

The Renaissance—the awakening of Europe from the semi-barbarism into which it sank after the western Roman Empire was swept away by invading hordes of Visigoths and Vandals—began in the 13th century in the city states of Italy, where literature, painting, and sculpture blossomed again through succeeding generations in the works of Dante and Giotto, Petrarch, Leonardo da Vinci and Botticelli, Raphael and Michelangelo, and many another gifted man. The capture of Constantinople by the Ottoman Turks in 1453, scattering through western Europe the scholars this last stronghold of Roman tradition had sheltered, brought the old learning to mingle with and enrich the new already spreading northwards from Italy.

Johann Gutenberg (c. 1400–68), who invented printing from movable type.

Gutenberg's invention in the 1440s of the printing press with movable types gave scholarship a scope it had never known before ; and with the consequent spread of knowledge men's minds developed a new inquisitiveness—concerning the world about them, and concerning the powers that had for centuries exercised unquestioned authority over the minds and bodies of the great majority of the people.

It was this curiosity that sent out the venturesome explorers in the last years of the 15th century into the vast distances of the unknown sea—Bartholomew Diaz who sailed south until in 1488 he rounded the Cape of Good Hope and opened the way for an eastward sea passage to the Indies ; Christopher Columbus who, sailing westward, in 1492 discovered the New World (though he never knew this, believing until he died that he had reached the far east of the Old World) ; John Cabot who, setting out from Bristol, in 1497 found Newfoundland.

Another event marking off medieval from modern history was the final expulsion of the Moors from Spain in 1492 when Granada fell to Ferdinand and Isabella : this was the culmination of the process begun by their marriage in 1469—he the heir to Aragon, she the queen of Castile—in which the Iberian peninsula outside Portugal became one country.

Europe in the 16th Century

When the 16th century opened, Louis XII had just ascended the throne of France. Maximilian, archduke of Austria, was Holy Roman Emperor, elective head of an empire that covered Germany and much of north Italy—though he had little enough effective control over the lay and ecclesiastical princes who ruled the separate principalities, dukedoms, counties, bishoprics that made up the empire. Maximilian had in 1477 married Mary, heiress of

LOUIS XII succeeded to a throne powerfully established in France and sought to acquire more territory by invading Italy. This miniature from a French MS. shows his entry into Genoa in 1507.

Charles the Bold, duke of Burgundy; on her early death her lands had passed to their son Philip, who in 1496 was married to Joanna, third daughter of Ferdinand and Isabella. A son, Charles, was born in 1500. Henry VII, the first Tudor, had settled his family firmly on the throne of England. Alexander VI, of the Spanish house of Borja or Borgia, was Pope—a man remembered as the father of Cesare and Lucrezia Borgia and for his own conspicuous lack of saintliness.

Within twenty years Francis I had succeeded Louis XII; Charles V, son of Philip and Joanna, was emperor, king of Spain, and lord of Burgundy—ruler of a territory larger than that of any of his contemporaries; Henry VIII was king of England. They were all young men, with strong ambitions. Leo X, a patron of art indifferent to religion, had become Pope.

Martin Luther

All through the Middle Ages secular princes had challenged the temporal authority of the Pope; but his spiritual authority had been unquestioned. The time had now come when this was to be challenged. The occasion of the challenge was the Pope's want of money. To get money he proposed to do as many of his predecessors had done—to issue indulgences for sale. Everyone who purchased an indulgence for a small sum was popularly supposed to be assured of pardon for his sins—though the Church itself added "on condition of repentance." Martin Luther, a professor at the university of Wittenberg in Saxony, had come to the conclusion that pardon for sin could not be purchased; that the power of forgiving sins did not lie with the Pope; and that indulgences were an enormous and blasphemous fraud. He affixed his denunciation of the indulgences to the cathedral door, and, having done so, he induced the elector of Saxony to forbid the papal commissioners to enter his dominions with indulgences for sale. Having thus thrown down the challenge he proceeded to urge upon the princes of Germany that all the customary papal exactions of tribute were an iniquity, and that the princes should cease their contributions to the papal coffers.

Burning of the Papal Bull

Princes who might not take any interest in theological problems were touched by the appeal to their pockets. The attack, moreover, involved the promulgation of doctrines altogether subversive of the authority of the Church of Rome—doctrines very much akin to those which had been set forth a hundred years before by John Huss and his English predecessor, Wycliffe. It seemed necessary to suppress the Wittenberg professor. Leo X issued a bull excommunicating him. On December 10, 1520, Luther publicly burnt the Pope's bull.

LUTHER IN THE PULPIT. Inspiring his hearers with his sincerity, Luther is seen in this contemporary German MS. in a characteristic attitude, attacking the corruption of Rome.

The meeting of the estates of the empire, called the Diet, was about to be held at Worms under the presidency of the young emperor. Charles, who desired the good will of the Pope, summoned Luther to attend the Diet to answer for himself. Luther stood by his doctrines. If he could be convinced they were false, he would recant, but he would not deny his faith.

The princes were divided; the churchmen were solid against Luther; the knights, the gentry, and the common folk were manifestly inclined to support him. His friends, for his own sake, kidnapped him, and hid him away in the castle of the Wartburg in Thuringia, while the Diet issued the Edict of Worms declaring Luther an outlaw and heretic. Luther, however, had some powerful protectors. The "good elector," Frederick of Saxony, was the most respected of all the German princes; the others were in no hurry to risk a civil war in order to punish a monk. Charles himself was already at war with Francis I of France, and wanted to secure the support, or at least the neutrality, of England, to whom France also was making overtures. A civil war in Germany at such a juncture would be embarrassing. He could afford to take no energetic steps for the suppression of Luther.

The Reformation

In the war that followed between Charles V and Francis I, England joined Charles ; and Francis, after some successes in the south—the actual cause of dissension was in Italy—was defeated and taken prisoner at the battle of Pavia, 1525. This for the time gave Charles an overwhelming predominance. The English alliance cooled ; the Pope, Clement VII, whose election Charles himself had procured, took alarm, and Charles, annoyed by his attitude, refused to enforce the Edict of Worms. A new edict at the Diet of Speier, 1526, virtually left the princes free to suppress or advance the Lutheran movement within their own territories. The next year Charles marched on Rome, sacked it, and took Clement VII prisoner.

FRANCIS I. A popular king, noted for gallantry and splendour ; from a portrait painted by Jean Clouet.

Very much as the Lollard movement in England in the reign of Richard II was accompanied by, though it hardly inspired, the Peasant Revolt, so, just before this, there had been a great peasant revolt in Germany, caused by the oppressive conditions under which the peasants lived, but associated by its leaders with the new religious doctrines. The demands of the peasants appeared wholly subversive of the existing social order. Luther, always a determined advocate of the civil government, repudiated the movement.

CAREWORN MAJESTY. Titian's portrait of the Emperor Charles V (1500–58), the mightiest potentate in Europe, who also ruled the vast Spanish dominions in America.

In Germany, Luther was recognized as a champion of law ; outside Germany, the new doctrines were regarded as the cause of the revolt, and Lutheranism as revolutionary. The very men who had been most active in recognizing the need of a moral reformation and a purification of the Church, humanists like Erasmus and Thomas More, were driven to the conservative side. Charles, having got the Pope into his own hands, was disposed again to revert to his anti-Lutheran attitude. This led to the protest of Speier, whence the Lutheran princes were called Protestants, a name afterwards extended to all who set themselves in opposition to the Papacy, whether or not they accepted the confession of Augsburg in which the Protestants formulated their creed.

The Lutheran princes, regarding their own authority in their own dominions as being at stake, then united in the league of Schmalkalden, 1531.

Advance of the Turks

Civil war in Germany was averted mainly because the Empire was threatened by the advance of the Turks and could not afford to plunge into internecine strife. Selim, who had killed his father and became sultan in 1512, had immensely increased the strength of his realm. He had established his rule over western Asia, subjugated the Egyptian Mamelukes, and procured his own recognition as caliph, the spiritual as well as the temporal head of Islam, although shortly afterwards the Shiite sect found independent rulers in the Sufi or Safawid dynasty which established itself in Persia.

Suleiman the Magnificent

Selim was followed by Suleiman the Magnificent. The Turkish fleets dominated the Mediterranean under his admiral Khair-ed-Din, called Barbarossa. Rhodes fell before the Moslem attack in spite of a heroic defence by the Knights of St. John. Belgrade was captured ; and in 1528 Suleiman advanced to the walls of Vienna, though he was unable to take the city. The menace did not suffice to unite the Germans, but it had a constantly distracting influence on the emperor's policy.

For Charles himself, religion was only a secondary motive. The primary one was his determination to give the imperial authority substance in Germany ; but accident had made religion the *casus belli* between emperor and princes. While Luther lived, open conflict was postponed. In England, Henry VIII was meanwhile carrying through his own unique conception of Reformation.

The "Interim"

Luther died in 1546. The deaths of Henry and Francis followed. Charles felt himself no longer shackled ; he decided to suppress the Protestants. If he could break up the League of Schmalkalden, it seemed that his victory would be assured ; and owing to the jealousies of many German princes he could count, or thought he could count, upon the support of two powerful Protestants, the elector of Brandenburg and duke Maurice of Saxony. With Maurice's aid, Charles struck at the League and captured both its chiefs. Then he put forth a compromise satisfactory to no one, called the "Interim," which was to be in force until a complete settlement could be arrived at through a general council of the Church. But besides aiming at a religious settlement, it was also Charles's intention to strengthen his own authority. Suddenly the emperor was attacked by duke Maurice, and barely escaped capture.

POWERFUL RULERS. Left, Catherine de' Medici (1519–89), queen of Henry II of France, mother of Francis II, Charles IX and Henry III, and for long the real ruler of the state. Right, Philip II (1527–98), king of Spain, the Netherlands and the Indies, and champion of Catholicism in Europe.

The tables were turned, and Charles was compelled to accept the pacification of Passau, 1552, which abolished his constitutional innovations, and established the principle that to whichever of the religions any prince chose to adhere, he should be free to enforce that religion within his own realm. At the same time, however, the Catholics were able to secure a provision, that any ecclesiastical prince who changed his religion was *ipso facto* required to resign his see—which seemed to ensure that the ecclesiastical territories should remain permanently Catholic.

DEFENCE OF RHODES. Rhodes fell in 1522. This woodcut, published some years earlier, shows an unsuccessful Turkish attack.

Persecution of the Huguenots

King Francis was succeeded by his son Henry II, a rigorous Catholic, who, within his own territories, dealt severely enough with the adherents of the reformed faith, in France called Huguenots. These, however, numbered among their leaders many of the nobility, and even princes of the blood, who were strong enough to prevent anything like a suppression of the reformed religion. In the ensuing reigns France was perpetually torn by the struggles between Huguenots and Catholics.

In 1556 the emperor Charles V abdicated in favour of his son Philip, who inherited Spain and the Burgundian lands ; Charles's brother Ferdinand, an orthodox but pacific Catholic, was in 1558 elected emperor. At an early stage of his career Ferdinand had acquired by election the crowns of Bohemia and Hungary (both outside the empire), thus laying the foundations of the 19th-century "dual monarchy" of

Austria-Hungary. In England Mary I was in 1558 succeeded by Elizabeth I. In 1559 Henry II of France died: three of his sons reigned in succession in the next thirty years.

It had long been obvious that the Reformation movement was disrupting Christendom. Western Christendom had for centuries acknowledged one Church. The only possible hope of preserving that unity lay in the meeting of a general council of the whole Church which should reach a concordat acceptable to all. But when at last a council met at Trent, in northern Italy, in 1545, the conditions laid down secured an unqualified predominance to the papal authority. Admission of the papal authority being postulated, the advocacy of Protestant doctrines was effectively excluded. Consequently the real work of the Council of Trent was not to arrive at a concordat at all but to define the papal position, excluding from the Church as heretics all who did not accept that position, and banning all doctrines which deviated from those laid down. The Council of Trent, which terminated in 1563, laid down the line of demarcation between the Church of Rome and all other Churches, and fixed the lines of the contest between the Reformation and the Counter-Reformation. Conveniently but misleadingly, the term Catholic has been for centuries the recognized label for all who accepted the claims of the Roman Church, the term Protestant the label for all who rejected them.

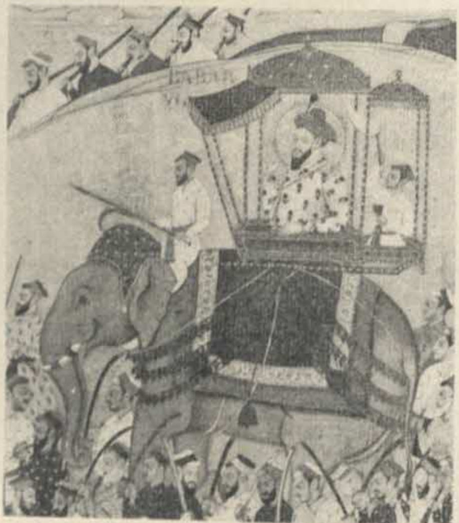
Those two labels will be used here because no others have been devised which are not equally open to objection. Churches which are not in the Roman communion claim the title of Catholic, while the title Protestant applies properly only to Lutherans who accept the Augsburg confession. But the terms remain the most convenient labels for marking the line of cleavage which for a century after the Council of Trent was to be a primary factor in international relations, wars, and alliances. Yet within the Protestant division there were antagonistic groups, hostility between the followers of Calvin and Luther preventing Protestantism from showing a united front; and zeal for reform was as strong in the Catholic as in the Protestant division, the Catholic Counter-Reformation producing that remarkable body, the Society of Jesus (the Jesuits).

LESSON 2

India and America Enter World Politics

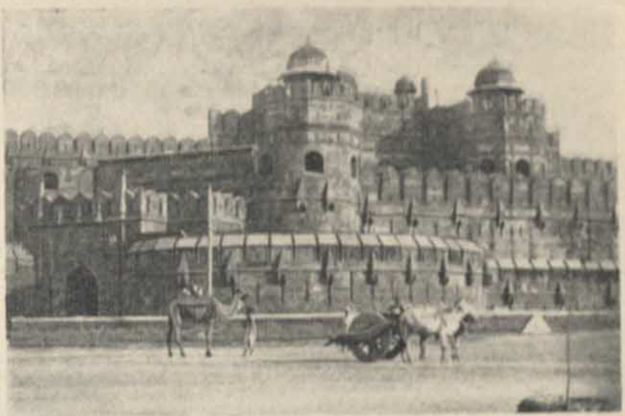
In the 16th century, following the voyages of Christopher Columbus in 1492 and Vasco da Gama in 1487, a Spanish and a Portuguese empire were established in America, and a Portuguese maritime empire in the Indian Ocean.

Simultaneously with the creation of this Portuguese empire, the Mogul empire was created in India. For centuries Hindustan—the northern half of India—had been under the dominion of Mahomedan conquerors reigning at Delhi who oppressed their Hindu subjects. At the close of the 15th century the last great Mahomedan empire had broken up, though Delhi still laid feeble claim to supremacy. The Portuguese in their operations had to deal, not with an empire, but with independent princes in whose hands lay the whole of the coastline. They established various trading stations—at Goa on the west coast of India, at Ormuz on the Persian Gulf, in Ceylon, and on the Spice Islands, or Moluccas, at the centre of the East Indies. From these posts they dominated the eastern seas.



BABAR ("the tiger"), founder of the Mogul dynasty in India. His real name was Zahir ed-din Mohammed.

But the conquest of India was left to Babar, half-Turk, half-Mongol, who had been dispossessed of the principality of Samarkand but succeeded in making himself king of Kabul. He turned his eyes upon Hindustan; his opportunity came for compensating himself in that region for his failure in central Asia when the governor of the Punjab invited his aid against the Lodi emperor at Delhi. Babar was a born commander. In 1525, with 25,000 men at his back, he invaded India. The king of Delhi met him on the field of Panipat; Babar won and made himself master of Delhi. The Hindu princes of Rajputana, by no means submissive to Delhi, resented Mahomedan rule; Babar crushed them in turn. The king of Bengal united with the adherents of the expelled Delhi dynasty: Babar crossed the Ganges, defeated his enemies, and became lord of all northern India within six years of the time when he had first invaded the Punjab. But Babar had effected a purely military conquest. He died, and his son Humayun was driven back to Afghanistan by the great warrior Sher Shah, who seized the throne of Delhi and seriously began the work of organizing an imperial administration. Then Sher Shah died; Humayun came back from Afghanistan, and recaptured Delhi. He died by accident in 1556, and was succeeded by his 14-year-old son Akbar (1542–1605).



AKBAR'S FORT AT AGRA. This immense structure, with massive red sandstone walls surrounded by a wide and deep moat, was built in 1566 by Akbar, the grandson of Babar and the greatest of the Moguls in India. His reign was an era of tolerant justice.

Akbar the Great

An able soldier, with immense powers of physical endurance, Akbar was naturally a conqueror; indeed, it was only by conquest that he maintained his dominion. Throughout his reign he continually faced the alternatives of attacking or being attacked. He, rather than Babar, was the true founder of the empire miscalled Mogul, for his father was more Turk than Mogul, his mother was a Persian, and the mother of the son who succeeded him, from whom the rest of the line descended, was a Rajput princess.

Akbar's title to fame does not lie merely in the fact that he mastered the whole of Hindustan, from the Himalayas to the Nerbudda, from Afghanistan to the Bay of Bengal. He also organized his empire. He made it his aim to unite the heterogeneous peoples over whom he ruled. He would make no difference between Hindu and Mussulman; he took wives among the daughters of Rajput princes. He abolished the special taxes to which the infidels had been hitherto subjected by all Mahomedan rulers. Hindus were among his most trusted captains and administrators. To a Hindu, Todar Mal, was entrusted the work of reorganizing the revenue system of the empire. His reign seemed to be the inauguration of a new era, in which Hindu and Muslim might live side by side. He was tolerant, in an age when no European sovereign dreamed of religious toleration; and he had also the wisdom to distribute his vast territories into governorships small enough to ensure that no governor should be in a position to set the central authority at naught.

VICTORIOUS CORTÉS. One of the fiercest battles fought by Cortés in Mexico was with the natives of Michuacan, near the Pacific seaboard, in which he was assisted by the Tlaxcalans with their war dogs. From an old Mexican painting.

In the 16th century English expeditions across the Atlantic discovered northern America, a region sparsely peopled by savages and offering few attractions. The Spaniards were settling in the tropical and fertile islands of the West Indies, occupied by peoples too primitive to offer resistance to Europeans armed with firearms. On the American mainland, the Spaniards reached the great isthmus and found traces of early barbaric civilization that had died out; they made contact with the Aztec empire of Mexico and the Inca empire of Peru—both believed to be fabulously rich in precious metals, but without iron, horses, or gunpowder.

Conquest of Mexico and Peru

The Spanish governor of the islands in 1519 sent to Mexico an armed embassy, headed by Fernando Cortés, a band of four hundred men with a smaller body of natives in attendance; a tiny troop to conquer an empire; but they had horses, armour, and a few arquebuses. Montezuma II, Aztec ruler of Mexico, sent envoys to meet Cortés, who announced himself as the representative of the mightiest of monarchs dwelling beyond the seas. Montezuma replied with a polite message and a present, but forbade the dubious stranger to enter his capital. Cortés disregarded the prohibition, and easily scattered such native forces as were sent to bar his advance; and when he reached the capital, Montezuma did not venture to resist.

The king was not to be persuaded to accept the Christian faith at a moment's notice, though he offered tribute and homage to the monarch whom Cortés represented. But the handful of Spaniards soon felt that the temper of the population was hostile and their own position extremely precarious. Cortés took the king into custody as a hostage. When Montezuma showed himself in public, the people attacked him as a traitor, and he was so seriously injured that he died, 1520.

Then Cortés and his band cut their way out. But the tribes with whom he had made friends on the march were called in; reinforcements arrived; the Mexicans realized that resistance was useless, and Cortés proceeded to establish and organize a government in the name of the king of Spain. Fresh troops from overseas were sent, and Mexico, or New Spain, was definitely attached to the Spanish empire, 1513.

Peru was ruled by the Incas, a dynasty of foreign origin. It was well advanced in the arts of peace; no foes threatened it; it was untroubled and prosperous; but it was unprepared for war, and from a European point of view was unarmed when Pizarro appeared with his troops. Pizarro, an illiterate foundling who had taken to the sea, in 1529 procured a commission for the conquest from the Spanish court. He started upon his adventure with 200 men, some horses, and some small cannon. He made his way down the Pacific coast till he reached Peruvian territory. The reigning king, Atahualpa, who had recently deposed his brother Huascar, never dreamed of danger from the little band of strangers; he welcomed them, and when they came near his capital he went down to their camp with many men to greet them. The Spaniards suddenly opened an attack upon their unsuspecting host. Their guns dealt destruction; before the charge of their armed horsemen the Peruvians fled and were cut down like sheep. Atahualpa himself was captured. In his helplessness he offered Pizarro a ransom. Pizarro accepted the offer, but his cupidity had been excited. Huascar plotted against Atahualpa, who put him to death. Pizarro, as the champion of the murdered prince, seized Atahualpa, executed him, and took charge of the government in the name of the king of Spain. Resistance was impossible, and the Inca empire was added to Spain in 1533. Cruel, treacherous, unscrupulous, and determined, Cortés, Pizarro, and their men had earned the name of "Conquistadores" (conquerors).

FORTRESS-TOWN OF THE INCAS. Machu Picchu, north-east of Cuzco, has a wild and desolately lovely setting. "Andenes" or cultivation terraces climb the precipitous sides of the narrow saddle on which it stands, and dizzy stairways lead from wall to concentric wall, the whole comprising miles of beautifully worked masonry. The sugar-loaf peak, dominating the town, is Huayna Picchu.

LESSON 3

The French Wars of Religion

Though the Council of Trent provided no concordat for Christendom and brought not peace but a sword, the peace of Augsburg, 1555, following the settlement at Passau, 1552, effected a practical pacification of Germany for fifty years. In England and in Scotland, the Reformation had triumphed even before the termination of the Council of Trent. Nothing but violent and successful interposition by foreign powers could have restored Romanism: in Scotland, because the mass of the population had become fervently Calvinistic; in England, because the title of Elizabeth I to the throne as the legitimate daughter of Henry VIII had been pronounced invalid by the Pope. Elizabeth, therefore, was bound to support Protestantism, which had gained a great deal of ground in spite of persecution by her predecessor and half-sister Mary I.

GASPARD DE COLIGNY (1519-72), leader of the French Huguenots, murdered during the St. Bartholomew massacre.
After Clouet

In Spain and Italy, Protestantism had no foothold. In France and in the Netherlands, neither religious party was decisively in the ascendant, though in France the Roman Catholics were stronger than the Huguenots; in the Netherlands the adherents of the reformed religion were the active party.

Overlapping Struggles

During the next half-century there were three overlapping struggles going on. That between Catholics and Huguenots in France prevented that country from intervening elsewhere. The second was the struggle of the Netherlands for religious freedom and for political independence from the Spanish monarchy, King Philip II of Spain being lord of this land which formed part of his Burgundian inheritance. The third was the newborn rivalry between Spain and England. In the second and third struggles Spain's antagonists triumphed.

In France, there came to be a zealous Catholic party headed by the Guises; a powerful Huguenot party among the nobles; and a Court party generally, though not always, on the Catholic side at home, but antagonistic to the European policy of Philip II.

When Henry II of France died in 1559, he was succeeded by his son Francis II, whose wife was Mary Stuart, the young queen of Scots, and for 17 months the crowns of France and Scotland were worn by the married pair. Francis died in 1560, and a younger brother succeeded as Charles IX. That prince was entirely in the hands of the queen mother, Catherine de' Medici, who had little love for Mary Stuart, or for Mary's uncles of the house of Guise, and was to be the real ruler of France for the next fifteen years.

Charles and his two younger brothers were all feeble in health; should they die leaving no male offspring the French crown would pass to their cousins of the house of Bourbon, Antony of Navarre and his son Henry, and after them to Antony's brother the duke of Condé. Navarre and Condé were Huguenots, so that there was an actual possibility of a Huguenot succession. The Huguenots were consequently a powerful party in the state.

The queen mother intended to be dominated neither by the Guises nor by the Huguenots. Her object was to form a middle party, which came to be known as the "Politiques," that would hold the balance between the religious factions—a policy which differed from that followed in England, where Queen Elizabeth I and her ministers aimed at establishing religion on a comprehensive basis: they wanted to penalise all those who stood outside the established Church, but to make the established Church wide enough to include all except on one side extreme Protestants, on the other devoted Roman Catholics. Catherine's aim was toleration, not comprehensiveness.

The hostility of the two religious parties in France was, however, too strong. When the Huguenots succeeded in obtaining relief from the restrictive edicts which were in force against them, they alarmed the middle party by the excessively radical demands they made at the States-General (French equivalent to British Parliament) in 1561—the first held for 77 years—and so drove the queen and the Politiques temporarily to the side of the Guises. A year later, finding some Huguenots worshipping in a barn at Vassy in Champagne, the duke of Guise ordered their dispersal and, when resistance was offered, put them to the sword. Guise became master of Paris, where the populace was furiously Catholic.

The result was a Huguenot insurrection. It is important to remember that the Huguenots,

PERSECUTION IN FRANCE. The massacre of the Huguenots, which began on St. Bartholomew's Day, 1572: from a picture painted by François Dubois, an eye-witness of its horrors. Although executed from memory, it was probably based upon sketches made at the time of the frenzied killings.

though a powerful, energetic, and well-to-do section of the community, mostly merchants and country gentry from the south-west of France and parts of Normandy, numbered only about one-twentieth of the people of France. They were led by Condé and Coligny, admiral of France. Then Guise was assassinated, and a truce was patched up between the parties by the treaty of Amboise, when the edict of toleration was confirmed. Catherine, however, was suspected of secret machinations with the duke of Alva, the lieutenant of Philip II, for the suppression of heresy, and a second war broke out in 1567. The Huguenots were defeated at Jarnac and Moncontour, and Condé was killed.

Catherine, now more afraid of the Guises than of the Protestants, began to favour the reformers. A reconciliation was to be effected by the marriage of Henry of Navarre to her daughter Margaret, celebrated at Paris in 1572, in which year also Henry became king of Navarre. But already a new alarm seized Catherine when she saw Coligny apparently gaining a dangerous influence over Charles IX.

Massacre of St. Bartholomew

The Huguenots looked upon the royal marriage as a triumph for their cause; vast numbers of them assembled in Paris to attend the celebration, and an unsuccessful attempt was made to assassinate Coligny. Its failure perhaps decided Catherine to commit herself to a Guise plot for a general massacre of the Huguenots in Paris. At dawn on St. Bartholomew's Day, August 24, the bell of the palace of justice gave the signal for a slaughter that lasted until October 3. The streets of Paris ran red with Huguenot blood, and it is probable that in Paris and the provinces, 25,000 were murdered, Coligny among them.

Catherine was quick to realize that she had blundered. She had violently alienated England. In France itself moderate men were shocked, and there was a reaction in favour of the Huguenots. Charles died. His brother, Henry III, was at once a bitter partisan of the Catholics and hostile to the Guises. The chances that the succession would go to his Huguenot cousin of Navarre were strong. His younger brother Francis died in 1584, and Henry of Navarre became heir-presumptive.

"War of the Three Henrys"

Already Henry of Guise had formed the Holy League to prevent the Bourbon succession. The king hesitated between the two alternatives, which were almost equally hateful to him, of supporting either Henry of Navarre or Henry of Guise. The confused hostilities which followed are called the "War of the Three Henrys." In 1588, the year of the Armada, the Guise faction got the upper hand, but at the end of the year their success was terminated by the assassination of Guise himself. It was followed eight months later by the assassination of Henry III.

Henry IV and the League

There followed the long struggle of Henry IV to secure the crown which was his by inheritance. The fact that Philip at this time made common cause with the Catholic League was embarrassing in particular campaigns, but gave the League itself an unpatriotic colour, of which Henry made full use. Yet the Catholic resistance was not broken down till Henry, secure of the Huguenots whatever he might do, announced his conversion and was welcomed into the Roman Catholic Church by the pope.

Edict of Nantes

The League surrendered; policy forbade penalisation of its members; and the liberties of Henry IV's Huguenot subjects were assured by the promulgation in 1598 of the Edict of Nantes. Catholic though he called himself, Henry's interests so far as concerned international affairs were entirely Protestant, and for practical purposes he became the leader of Protestant Europe. In France his reign was marked by a vigorous administration and stringent financial reforms directed to the benefit of his subjects, wherein his chief minister was the eminent Huguenot, Sully. It was also distinguished by that concentration of political control in the hands of the king which reached its highest development with his grandson, Louis XIV. He fell by the dagger of an assassin in 1610, at the moment when he was organizing a great Protestant combination intended to check the increasing power of the two Hapsburg dynasties.

LESSON 4

Spain's Bid for World Supremacy

When Queen Mary I of England, first wife of Philip II of Spain, died in 1558, neither Philip nor anyone else imagined that England was the rock upon which his ambitions were destined to be wrecked. To all appearances he was incomparably the most powerful potentate in Europe, and England a feeble power to be feared only if she were joined in close alliance with France. The overthrow of Elizabeth I was the last thing he desired, because the alternative to her was her cousin, Mary Stuart, Queen of Scots, wife of the Dauphin of France who succeeded to the French throne as Francis II in 1559.

Elizabeth, then, felt herself secure against the open hostility of Spain; and while she was free to foster the spirit of Protestantism, English sailors were discovering that their seamanship was superior to that of the Spaniards. They were determined to force open the door of trade with America which Philip sought to keep shut, and were increasingly bitter against Spain because captured English sailors were dragged before the Inquisition as heretics. Thus there developed in England a spirit of intense antagonism to Spain, and a determination to prove that England, not Spain, was mistress of the seas.

DUKE OF ALVA, Fernando Alvarez de Toledo (1508-83), sent by Philip II to crush rebellion in the Netherlands.

The death of Francis II in 1560 reduced the danger, from Philip's point of view, of Mary Stuart's possible accession to the English throne; but Philip became more and more deeply involved in his endeavour to master the Netherlands, and until that was accomplished he was disinclined to turn against England.

In the struggle with the Netherlands, Philip had a double object. He meant to subdue them politically and to carry out there his self-imposed mission as the destroyer of heresy. The disdain with which Philip ignored the ancient privileges of the Netherlandish towns and universities, and his sanguinary edicts against heresy—under which the slightest sympathy with the Reformers was punishable by death at the stake—excited the hostility of Catholic and Protestant alike. Open revolt resulted from the tyranny of the merciless duke of Alva, who was sent to the Netherlands as military governor. Though Alva imagined that he had crushed insurrection for good and all, the conflagration burst out again in 1572 and was not quenched until the United Provinces (the Dutch Republic) achieved independence under the leadership of the house of Orange in the 17th century.

England under Elizabeth I

Every attempt by Philip to dictate to Elizabeth, every plot fostered by his agents, every story of the audacious doings of English sailors or of their sufferings at the hands of the Inquisition, intensified the ever-growing sentiment in England in favour of challenging Spain and standing forward as the champion of the Protestants of Europe.

WILLIAM THE SILENT, prince of Orange (1533-84), leader of the revolt against Spanish oppression.

By shifts of incredible ingenuity, and helped by a luck which never deserted her, Elizabeth put off the struggle year by year, knowing that time was in her favour. Philip lived under the illusion that the longer he delayed his stroke the more completely he would overwhelm the rival who troubled, but did not alarm, him. The Netherlanders held out grimly, while the queen of England doled out to them just enough financial help to save them from being

THE ENGLISH FLEET ENGAGING THE "INVINCIBLE" ARMADA. Lord Howard of Effingham was the admiral in command of the English fleet that routed the Spanish Armada, and some time later he employed a Dutch artist, H. C. Vroom, to design a series of tapestries illustrating the English triumph. A part of the panel showing the fight in the Channel, July 21, 1588, is reproduced above.

completely defeated. English volunteers fought on the Dutch side.

Not until Elizabeth I had been on the throne for 27 years was there open war between the two countries though long before that the English mariners had been treating Spanish ships and Spanish ports as legitimate prey, and Francis Drake had sailed round the world and returned to Plymouth carrying in his ship, the Golden Hind, treasure looted from the Spaniards reputed to be worth more than a million sterling—for which Elizabeth knighted him, instead of having him hanged for piracy as Philip demanded.

In 1585, when the English and Spanish governments were supposed to be in amity, the irritated Philip seized all English ships in Spanish ports. Elizabeth at last had openly to ally herself with the rebels in the Netherlands.

The Armada Sets Sail

After Francis II's death Mary Stuart had returned to her kingdom of Scotland. There she married her cousin Lord Darnley, to whom she bore a son. Darnley was murdered in 1567, and Mary then married Bothwell, thought to have planned Darnley's murder. Her subjects rose in arms; Mary abdicated in favour of her son, James VI (later James I of England), and fled to England. In 1587, after 18 years of captivity in England, Mary was executed on the charge of complicity in the Babington plot for the assassination of Elizabeth and her own elevation to the English throne. By her will she left Philip the heir to her claims. Philip prepared a mighty armada—it was already fairly advanced when Mary was beheaded—and, though Drake scoured the seas and in 1587 burnt the shipping in the harbour of Cadiz, in 1588 the Great Armada put to sea to destroy the heretic queen. It was to sail to the Netherlands, and to convoy to the shores of England the veteran army of the duke of Parma, the greatest soldier of the age, who was relentlessly restoring, with the help of Spanish arms, Philip's authority over the rebellious Netherlands.

Defeat of Spain

There was a running fight up the Channel lasting for a week, with one sharp engagement off Gravelines which drove the Spaniards to take shelter in Calais roads. There, as the Spanish fleet lay at anchor, English fire-ships sailed in among them. The Spaniards cut cable and, in disorder, made for the open sea where the English fell on them and shattered the scattered fleet. A number of Spanish ships fled round the north of Scotland; caught by a tempest, many were broken to pieces on the rocky coasts by the wind and waves. Fewer than half the 130 ships that composed the Great Armada found their way back to Spanish ports.

The fate of the Armada showed that mastery of the seas lay with ships manned by mariners who handled each individual vessel as an instrument of war, not with sea castles crowded with soldiers. It proved that the palm of seamanship and of naval fighting had passed to the English.

The defeat of the Armada rang the knell of Spanish power. The king of Spain was parted by sea from his possessions in Italy; Spanish troops and Spanish supplies could not reach the Netherlands unless they ran the gauntlet of the Channel, now virtually closed to any shipping the English did not favour. The people of the Netherlands maintained their stubborn defiance. The southern Netherlands (the land that was in 1839 to be recognized as Belgium) was subdued; but, with the death of Parma in 1592, Philip's chance of subduing the north receded; the United Provinces (that is the area constituting the kingdom of the Netherlands from 1839) were, in fact, independent in all but name 40 years before their freedom was formally recognized in the treaty of Westphalia, 1648.

Eight years before the Spanish Armada Philip had annexed the crown of Portugal. His claim lay through his mother, the sister of the last Portuguese king; whereas the stronger claim lay with Catherine of Braganza, the daughter of that lady's younger brother—since a brother has precedence of a sister, and his daughter has precedence of his sister. Catherine's husband, however, did not venture to assert her title; so Philip was able to usurp the throne. The kingdoms remained separate; but the naval resources of Portugal were added to those of Spain—and were also laid open to the attack of English mariners.

LESSON 5

The Thirty Years War

In 1603 James VI of Scotland, the son of Mary Queen of Scots, succeeded to the throne of England as James I, in right of his descent from Margaret, the elder sister of Henry VIII, all of whose children had died without offspring. Thus James inaugurated in England the Stuart dynasty which had already been reigning in Scotland for more than 230 years. Philip II of Spain had died five years before his great rival, Elizabeth I. Henry IV and the Bourbon dynasty were securely established on the French throne.

Although during the next 50 years England occasionally intervened in European politics, she played only a minor part in them. She was mainly occupied during the greater part of the time with a struggle between Crown and Parliament that crippled her activities abroad.

Far-Sighted Diplomacy

France was occupied with her own consolidation and development, and the building up of the absolute authority of the crown under Louis XIII and Louis XIV by their respective ministers, Cardinal Richelieu (1585–1642) and Cardinal Mazarin (1602–61). But France had both the power and the will to intervene vigorously in arms when it suited her, and, when it did not suit her, to push her own interests by an astute and far-sighted diplomacy which, by 1660, had raised her to the position of the most powerful state in Europe. Germany, a great disturbing influence, was the storm centre of Europe at this period. There the superficial pacification effected by the peace of Passau and the treaty of Augsburg, 1555, was followed by the fearful struggle, 1618–48, called the Thirty Years War, a conflict which raged over almost all Germany.

The House of Hapsburg

The imperial crown, although it was elective, had become virtually settled in the House of Hapsburg. Frederick III, in the 15th century, had been succeeded by Maximilian, Maximilian by his grandson Charles V, and Charles V by Ferdinand, his brother, whose son and grandson had followed him. These Hapsburg

DEFENESTRATION OF PRAGUE. Bohemian rebels hurl two imperial officials, Martinitz and Slavata, from a top-storey window of the Hradcany Palace, Prague, May 23, 1618; from an engraving made soon after the incident, which precipitated the Thirty Years War.

emperors had aimed at compromise and toleration ; but Rudolph II (emperor 1576–1612), brought up at the Spanish court, seemed bent on following the example of his kinsmen in Spain, and becoming a champion of Roman Catholicism.

The peace of Augsburg had recognized Lutheranism but not Calvinism, the rather different form of Protestantism developed by Luther's follower John Calvin (1509–1564). Some of the leading princes had by now joined the Calvinistic body of Reformers. Between them and the Lutherans there was no love lost. They had more to fear from a Catholic reaction than the Lutherans and were actively promoting the formation of a league, nominally for self-defence, which had called forth the counter-formation of a Catholic league, also nominally in self-defence, in which the chief mover was Maximilian of Bavaria. The Augsburg pacification had laid down the rule, called the Ecclesiastical Reservation, that a bishop or abbot turning Protestant must resign his office ; but the Protestants had successfully claimed that there was nothing to prevent the chapter of the see from electing a Protestant when there was a vacancy, so that there were now several Protestant bishops.

BOHEMIA'S "WINTER KING." Frederick, Elector Palatine, chosen king of Bohemia Nov. 4, 1619, and driven from his kingdom a year later; hence the nickname "Winter King."

Defenestration of Prague

In 1612 Rudolph died and was succeeded by his brother Matthias, who had no children but held the crowns of Bohemia and Hungary as well as the archduchy of Austria. Matthias recognized his nephew Ferdinand of Carinthia as his heir. Protestantism was dominant in Bohemia, and the Bohemians claimed that the crown of Bohemia was elective, as, in fact, it always had been. They did not want Ferdinand for king. Even before Matthias was dead the Bohemian nobles rebelled, entered Prague in arms, hunted out the two officers who had been placed in charge of the administration, and pitched them out of a top-storey window of the Hradcany Palace : they fell on a dung heap and so escaped with their lives ; but this outrage, called the "defenestration of Prague," precipitated a war which lasted for 30 years. The Bohemians offered the crown on the death of Matthias in 1619 to one of the great princes of the empire, the Calvinist Elector Palatine, Frederick (who had married Elizabeth, daughter of James I, and, through their daughter Sophia, was the ancestor of the House of Windsor ; the prince Rupert who was a prominent cavalry leader in the English civil war was also their child).

The Catholic princes of Germany objected to the acquisition by the Elector Palatine of a second vote in the Imperial College of Electors as king of Bohemia—the king of Bohemia being an elector *ex officio* ; even the Protestant princes were dismayed by such an expansion of his power. The Catholic princes united to oppose him, and when Frederick attempted to establish himself in Bohemia he was defeated near Prague, 1620, and the Bohemian rebels were mercilessly penalised. The Austrian Hapsburgs had procured the aid of their Spanish kinsmen, whose troops poured out of the Spanish Netherlands into the Palatinate. The Elector Palatine and his wife took refuge in the United Provinces.

The English parliament was quite willing to intervene, but its short-sighted idea of intervention was to attack Spain. It was just at this time that George Villiers, duke of Buckingham, had acquired complete control over both the old king and the son who was to succeed him as Charles I. Also it was at this time that Richelieu was beginning his career as the controller of French policy. The Anglo-Spanish alliance, to which James had devoted himself throughout his entire reign, was broken up, and for it was substituted a very half-hearted Anglo-French alliance. Mismanagement of the English expedition sent to help the Elector ruined the chances of effective English intervention in Germany. Richelieu—who, like Henry IV, would suffer no extension of the Hapsburg power—on his part had to postpone effective measures on account of an insurrection of the Huguenots. In England Buckingham had no real policy, and carried King Charles into a quarrel with the French, which, in its turn, brought to a head the quarrel between the Crown and Parliament. Charles tried to get on without summoning parliament, and found it impossible to raise the funds necessary for war. When he did summon a parliament again, in 1640, it was the prelude to the outbreak of the civil war.

Career of Wallenstein

Now a new actor appeared on the scene on the imperial side, Albert of Waldstein, better known as Wallenstein (1583–1634). The Catholic league under its general, Tilly, had hitherto won Ferdinand's victories for him. Ferdinand was short of money, and the troops lived by pillage. Wallenstein, a Bohemian who had taken the imperial side, offered to raise an army which should be supported by enforced contributions from local rulers. A rich marriage gave him the means of recruiting soldiers on his own account. The opening years of the war revealed his military genius. As he did not share the religious intolerance of his age, his object was not the suppression of Protestantism but the complete establishment of the authority of the emperor through the commander-in-chief of the imperial armies—himself—who would, in effect, be master of the situation.

Albert von Wallenstein (1583–1634). Military genius of the Thirty Years War.

Wallenstein was successful ; in 1623 he was created a prince of the Empire, in 1625 duke of Friedland, in 1628 duke of Mecklenburg. The Catholics of the league, however, saw that it was not their objects that were being carried out. Ferdinand found himself obliged to choose between the league and Wallenstein. In order to conciliate the four Catholic electors, since he wished to secure the imperial succession for his son, Ferdinand emphasised the Catholic character of his policy by issuing, in spite of Wallenstein's protests, the Edict of Restitution, 1629, restoring to the Church all the estates which had been secularised by Protestant princes since the Pacification of Passau in 1552. Wallenstein went into retirement and most of his army was disbanded.

CARDINAL RICHELIEU. Chief minister of France, 1624–42. His aims were to aggrandise France, strengthen the crown, and prevent the consolidation of Germany.

Cardinal Richelieu throughout the period of his power (1624–1642) aimed to strengthen the monarchy by crushing the Huguenots and nobles who threatened the power of the king ; to keep Germany from consolidating ; to extend France to the Rhine, at the expense of Spain and of the Empire, and to establish a footing in northern Italy. In 1627 the French government troops attacked La Rochelle, the stronghold of the Huguenots. After enduring a long siege, and despite assistance from English troops under the command of Buckingham (who was assassinated at Portsmouth in 1628), the Huguenots were starved into surrender by the completeness of the blockade. Richelieu deprived them of their fortresses, but confirmed their rights and privileges as originally conferred by the Edict of Nantes. The Huguenots ceased to be a source of danger to the royal government ; while further complications with England were obviated by Charles I's struggle against Parliament at home. To check the Hapsburgs, who seemed likely to unite Germany and, as they also ruled in Spain, would then threaten France from both south and east, Richelieu needed a strong and ready ally to fight for him " la guerre couverte " till he was himself prepared to intervene.

Gustavus Adolphus of Sweden

Richelieu's agents worked for the dismissal of Wallenstein and for the intervention of Gustavus Adolphus, king of Sweden, one of the greatest commanders in history. A man of religious principle and taste, a linguist with a fine presence, the Swedish king was already a skilful leader and statesman. Though his country was large, its population was small, and his army numbered only 30,000 to 40,000 men. But it had already defeated the Russians ; it was well disciplined, well led and, above all, well armed and equipped on new lines, with a view to greater rapidity of movement. Richelieu helped to negotiate a treaty between Poland and Sweden so that Gustavus should be free to enter Germany where, after Wallenstein's dismissal in 1630, the struggle resolved itself into one between Catholics and Protestants.

Only a small section of Protestant Germany had hitherto taken active part in the conflict. The Lutherans hoped for the withdrawal of the Edict of Restitution, and they showed no eagerness whatever for rescue by any foreign champion. At this stage it was open to the Emperor Ferdinand either to adopt a policy of conciliation, and to bid for the friendship of the Protestants by a treaty based on the revocation of the Edict of Restitution, or to adopt the imperial policy of Wallenstein, or to place himself in the hands of the Catholic league—the course which he actually adopted. Even so, Protestant Saxony and Brandenburg would have persisted in neutrality—being by no means willing to see the Swedes in control of the Baltic, which would be the inevitable result if Gustavus won a decisive victory. But the edict restored Protestant Magdeburg, capital of Saxony, to the Catholics. This flourishing commercial city fell before the attacks of Tilly, commander of the troops of the Catholic league, and its inhabitants were massacred in an orgy of cruelty that shocked Europe. Both Saxony and Brandenburg forthwith joined in alliance with Gustavus, who advanced to a brilliant career of victory. Tilly was completely put to rout at Brietenfeld, 1631 ; in the next year, 1632, he was killed. Wallenstein was reinstated on his own terms as commander of the imperial armies. He met Gustavus on the field of Lützen, 1632, where the Swedes were victorious, but at the cost of their leader's life.

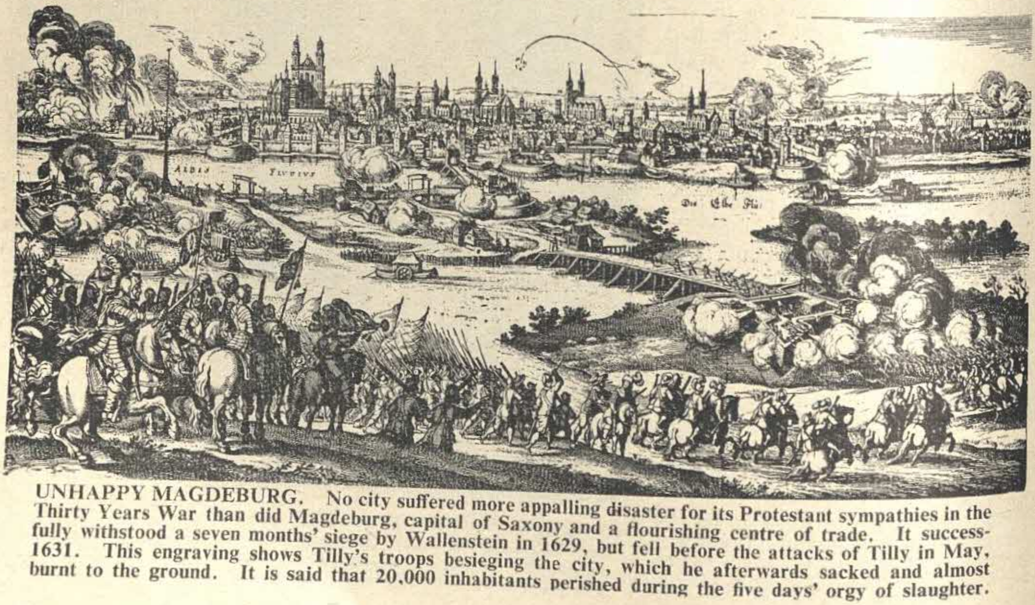
GUSTAVUS ADOLPHUS (1594–1632), king of Sweden (1611–32). He intervened on the Protestant side in the Thirty Years War, but was killed in the hour of victory at Lützen.

The death of Gustavus changed the character of the war. When he disappeared there was no one to unify and to co-ordinate the diverse aims of the heterogeneous groups on the Protestant side. Germany became the battleground of French, Spanish, Austrian, and Swedish mercenary armies which, living by plunder, reduced the country to a state of terrible misery. The incurable antagonism between Wallenstein and the league led to the second dismissal of Wallenstein in 1634 and his subsequent assassination—a crime to which the emperor is believed to have been a party.

At the end of 1634, after an imperial victory at Nördlingen, it became sufficiently obvious that, though the principles of the Edict of Restitution could never be enforced in the north of Germany, Protestantism would be unsuccessful in the south. In 1635 a treaty was entered upon, called the peace of Prague ; but this conciliated only some of the Protestant princes, and failed to combine Germany against the French and the Swedes.

France Secures Alsace

France now declared war upon Spain, since she was determined to sever the belt of Hapsburg territory which stretched down her eastern border. The continuity of this territory destroyed that isolation of the Spanish Netherlands



UNHAPPY MAGDEBURG. No city suffered more appalling disaster for its Protestant sympathies in the Thirty Years War than did Magdeburg, capital of Saxony and a flourishing centre of trade. It successfully withstood a seven months' siege by Wallenstein in 1629, but fell before the attacks of Tilly in May, 1631. This engraving shows Tilly's troops besieging the city, which he afterwards sacked and almost burnt to the ground. It is said that 20,000 inhabitants perished during the five days' orgy of slaughter.

that had been a factor of such importance in the struggle between Philip II and the United Provinces.

The cardinal's policy achieved a decisive success when Alsace was, in 1638, torn from the Hapsburgs by Bernard of Saxe-Weimar, on whose death in the following year the French themselves seized it. The appropriation of Alsace cleared the way for the extension of the French frontier to its " natural boundaries "—in other words, the Rhine valley—which was the essential feature of Richelieu's aggressive designs.

Peace of Westphalia

Before the next campaign in 1645, Louis XIII of France and Richelieu were both dead. Both sides were becoming thoroughly exhausted by the continuous devastation which had been inflicted upon the whole of Germany, and in 1648 the struggle was brought to an end by the series of agreements called collectively the peace of Westphalia. The pacification followed the lines of the old pacification of Augsburg, but with this difference—that all secularisations down to 1624 were confirmed, and Calvinists were placed on the same footing as was accorded to Lutherans alone in the earlier treaty. France got Alsace; Sweden got Pomerania, and with it the control of the Baltic ; Brandenburg, too, got an extension of territory. Europe formally recognized the United Provinces, or the Dutch Republic, as an independent state, and the Swiss Confederation was separated from the empire.

The special legacy of the war was the decline of Germany. It is calculated that nearly half the population died or were killed during the struggle. Its economic effect was most visible in agriculture, vast tracts of land going out of cultivation. Trade in the cities and seaports was also adversely affected, and England acquired most of Germany's traffic by sea. The power of the Holy Roman Empire was destroyed ; and it was not until, in the very different conditions of the 19th century, Germany was unified under Prussian rule that the German people emerged from a state of weakness.

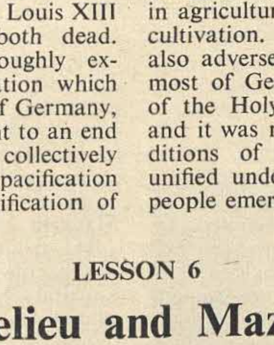
LESSON 6

Richelieu and Mazarin

After the assassination of Henry IV of France and the accession of the child Louis XIII, control of the government, until in 1617 Louis assumed power, lay in the hands of the queen mother, Mary de' Medici, who was entirely under Catholic influence and failed to maintain the conciliatory policy of her husband. There were several years of chaos and civil war ; then Louis placed his confidence in Richelieu.

Richelieu was no bigot. His struggle with the Huguenots was directed less against the Huguenot religion than against the political factions which used religion as a cloak. French Protestantism at this period was disruptive and reactionary. The cardinal was resolved on the establishment of a strong central government. All administrative functions were concentrated in the hands of the king, and royal officers and intendants—nominees and agents of the government—were appointed to superintend local administration, in place of members of the aristocracy.

The liberties of the Huguenots, as such, secured to them by the Edict of Nantes, were not curtailed. Before his death Richelieu had confirmed the principle of toleration ; he had made the crown supreme while he acted as its minister, and his policy had almost ensured that it should continue supreme after his death. Partly by arms, and still more by diplomacy, he had played a large part in checking the imperial successes by bringing about the intervention of Gustavus in the Thirty Years War. He had secured Alsace and prepared the way for a contest with Spain for possession of the Spanish Netherlands.



CARDINAL MAZARIN (1602–61). An Italian by birth, he succeeded Richelieu in 1642 as chief minister of France.

His death was followed almost immediately by that of Louis XIII, who was succeeded by his four-year-old son, Louis XIV. The regency fell to the queen-mother, Anne of Austria, sister of Philip IV of Spain ; but, contrary to expectation, she did not reverse French policy in relation to Spain. She chose as her minister another cardinal, the Italian Mazarin (1602–61), a man of a different type from his patron, the masterful Richelieu. Mazarin, however, continued his predecessor's policy of centralisation of power.

Early in the 17th century naval development had been arrested in England by maladministration, and supremacy at sea had passed to the Dutch. James I had not been in happy relations with Parliament. After his death the wrangling between Crown and Parliament developed under Charles I into civil war—a constitutional struggle that kept England out of action on the Continent. But in 1649 the Commonwealth government set about a vigorous reorganization of administration, notably of the navy.

Since the basis of the Commonwealth was Puritanism, it might perhaps have been anticipated that the Commonwealth would have sought a close alliance with the Dutch Republic ; but the English republicans proposed to challenge Dutch naval and commercial supremacy. England had all the material for the creation of a supreme navy—she had the seamen, she had at last a first-rate naval administrator in Sir Henry Vane, and admirals of high quality appeared among the soldiers who had fought in the civil war.

Cromwell's Foreign Policy

England threw down the challenge to the Dutch, and for some three years a stubborn contest was waged between Dutch fleets, led by Tromp, and English fleets, commanded by Robert Blake. The result was inconclusive, though on the whole in favour of England.

Cromwell as Protector was willing enough to close the Dutch quarrel ; it was his great desire to head a Protestant combination. Both Spain and France sought his alliance ; he came to the conclusion that Spain was the true enemy of Protestantism, and attacked her—first on his own account, with the consequence that Jamaica was captured, and then in conjunction with France.

War of the Fronde

The peace of Westphalia had not stopped the contest between France and Spain, which, unlike the struggle in Germany, had in it no colour of a struggle between the two religions. At the battle of Rocroi, 1643, the Spanish forces were annihilated by the northern French army under the duc d'Enghien (Condé). Henceforward until Waterloo the French usually held the military supremacy in Europe. Soon afterwards France was again handicapped by civil war. The removal of Richelieu's strong hand gave the opening for a renewal of civil disturbances called the War of the Fronde, 1648–53. This had its origin in the intrigues between particular nobles desirous of capturing the government and substituting their own control for that of the central authority which had been created by Richelieu.

Mazarin and England

Mazarin triumphed over the opposition. He was hostile to the regicide Commonwealth in England, but realized the advantage to be gained from an English alliance. Aided by Cromwell's troops, the French general Turenne overran the Spanish Netherlands. Dunkirk was captured and, in accordance with the terms of the English alliance, was handed over to England. But the death of the Protector, 1658, and the ensuing confusion in Great Britain prevented England from asserting herself. Mazarin was enabled to appropriate all the fruits of the alliance, unhampered by English demands, when the war was brought to an end in 1659 by the Treaty of the Pyrenees. France resigned her claims upon Italian duchies which had hitherto been a cause of dispute between France and Spain, but her position in Alsace was recognized, and she obtained the cession of some frontier territories, including several fortresses in the Spanish Netherlands.

During the last twenty years Spain had almost completely lost her hold

WAR OF THE FRONDE. This old print shows an engagement of the Fronde, when Condé on July 2, 1652, was hemmed in by royal troops under Turenne at the Faubourg St. Antoine, Paris. The citizens opened the gate of St. Antoine to the Frondeurs, and the guns of the Bastille battered Turenne's army.

upon Portugal. About 1640 the House of Braganza had asserted the title to the crown which had been ignored by Philip II in 1580 France, at war with Spain, had supported the Braganza claim, and by 1660 the Braganza monarchy was *de facto* established.

In 1660 the young king of France, Louis XIV, married Maria Teresa, daughter of the king of Spain; the marriage was accompanied by a qualified renunciation of any claims that time might give her to the Spanish succession, but left open the possibility of the ultimate accession of a Bourbon prince, if not of a French king, to the Spanish throne. In 1661 Mazarin died. A year earlier he had retired from the active control of the state, which had been assumed by the young king. Louis XIV stands out in French history as "*le grand monarque*," and it is claimed that during his reign France reached the zenith of her greatness.

LESSON 7

Louis Quatorze: Le Roi Soleil

Louis XIV took over the reins of government in France just about the time when his cousin Charles II was restored to the thrones of England and Scotland. With astute tenacity of purpose and able diplomacy, veiled by an assumption of licentious frivolity, Charles eventually procured from his cousin of France the funds which placed a small standing army at his (Charles's) disposal without the necessity of calling a parliament. The price he paid was a promise not to aid the enemies of France (i.e. the Dutch) and a secret promise, never kept, to establish Roman Catholicism in England.

Louis XIV Assumes Control

On Mazarin's death, the young king at once advised his secretaries of state that he meant to be his own prime minister—and so he was for more than half a century (1661–1715). Handsome, gallant, and splendidly dressed, he appeared soon as the sun among a radiant constellation of courtiers. The king who made Versailles loved display; his extravagance was deliberate, for the nobles who delighted to spend their time and money there had no resources to stir up those civil troubles in the provinces which had drained the strength of France for a hundred years.

Louis' abilities were not first-rate, but he was shrewd: he had learnt diplomacy from Mazarin, the art of war from Turenne, and the art of love at his mother's court. Mazarin himself said of the young monarch that "he had in him the makings of four kings and of one honest man." He was a hard worker. But he was vain, egotistical, and imbued with the contemporary political theory of the divine right of kings—the idea that the king can do no wrong and that his interests are those of the state: "*L'état, c'est moi.*" He had, however, the quality of recognizing talent in others, and surrounded himself with efficient ministers. Amongst these Colbert (1619–83) predominated. The state finances were placed under his direction, and although his policy was later nullified by the king's persistent extravagance, he was successful in reorganizing the financial system.

LOUIS XIV. Born in 1638, he succeeded to the throne in 1643. *From a portrait by Nicolas Mignard*

During his period of office Colbert, who was of Scots ancestry and descended from a family of cloth-weavers, controlled the arts in the service of the state. Tapestry at the time was in wide use throughout Europe. In 1662 Colbert combined all the tapestry factories round Paris into one—the Gobelins factory—and the court painter, Le Brun, was made director of work. Royal factories at Beauvais and at Aubusson were opened, and for a time contributed large sums to the exchequer. The leading French artists—Poussin, Watteau, Boucher, Fragonard among them—influenced and made designs for this prosperous state-run industry. Furniture was produced as well as tapestry. The striking feature of Colbert's domestic policy is his use of elements of a later industrial age—the factory and the large-scale investment of capital.

French Colonisation

At the same time Colbert initiated the maritime and colonial policy which was presently to result in a desperate struggle for empire between France and Britain, and which, more immediately, raised the French navy for a brief moment almost to an equality with that of England or of the Dutch Republic. He saw the possibility of a colonial empire sucking up French goods like a sponge, and he founded, or tried to develop, commercial companies as agents of colonisation. Two only—the East India and the Canada companies—enjoyed any

LOUIS XIV AT THE GOBELINS FACTORY. The famous dyeing and tapestry weaving works in the Faubourg St. Marcel, named after Jean Gobelin (d. 1476), were organized by Colbert, on the king's behalf, in 1662. Le Brun was in charge; he made this sketch showing a visit of Louis XIV to the factory.

prosperity. The former's was short lived, as it failed to receive adequate public support ; but Colbert's emigration scheme for Canada—sending out strong farm hands and country girls yearly—had some success. On the whole, however, this also failed, for the reason that the French were not inclined to rove, and the colonies were too far away for the people to be interested in them. In his schemes, Colbert's real enemy was the national character. French investors preferred certain and rapid small returns to problematic and distant gains. Frenchmen were no readier to leave their own soil in those days than they are now. Colonisation in its initial stages needs not only money but determined world-adventurers prepared to take plenty of risks.

COLBERT (1619–83), Louis XIV's finance minister, who also developed French overseas colonies.

Meanwhile, trade rivalry between England and the Dutch had caused a second war, in which both sides fought with obstinacy under able leaders. It would be hard to say that either side proved its superiority, though the Dutch accepted a treaty under which the principal advantages went to the English, to whom, among other things, was surrendered the colony which the Dutch had thrust in on the coast of North America between the New England colonies on the north and the plantation colonies on the south. When New Amsterdam became British, and was renamed New York, the whole North American seaboard of the modern United States, except the Spanish colony of Florida, was held by the English. Louis viewed the Anglo-Dutch quarrel with equanimity. The Dutch Republic was becoming hostile to France, for some at least of the Dutch were realizing that Spain in the Spanish Netherlands was now by no means so dangerous to them as France would be in the same territory—and Louis had already begun his policy of expansion.

Louis' aggression was based on a technical plea, which was ingenious but not convincing. He discovered a local custom of succession, which, if it had been a clearly recognized law, would have made his wife the heiress of the Spanish Netherlands instead of her brother Charles II (who had just succeeded to the crown of Spain) because that youth was the son of his father's second wife, whereas Louis' wife, Maria Teresa, was the daughter and only surviving child of the first wife.

War of Devolution

Spain naturally repudiated this novel doctrine; Louis promptly invaded the Netherlands and Spanish Burgundy. His progress was rapid ; the war consisted mainly of sieges, and Louis had the advantage that in Vauban he had one of the ablest military engineers of all time at his command. Lille, which he besieged in 1667, was forced to capitulate. Popular sentiment in England was perturbed ; there was an inclination to prefer a Spanish alliance, which was commercially profitable, to that with France. King Charles of England, with his own (unpublished) objects in view, was afraid that Louis was not sufficiently alive to the value of his support ; therefore he gave a cheerful assent to the project of an alliance, which was negotiated in 1668, between England, the Dutch Republic, and Sweden, with the avowed object of compelling Louis to come to reasonable terms with Spain.

Louis accepted the terms, but he could afford to do so, because he had just made a private agreement with the Emperor Leopold of Austria, who had married a younger Spanish princess.

There was no likelihood that the Spanish king would ever have children, and the two potentates bargained that, on his demise, which was expected at an early date, the Spanish kingdom was to be the inheritance of the Austrian empress, and the rest of the Spanish dominions were to go to the French queen. On those terms Louis could afford to wait, especially as the agreement left him in possession of the fortresses he had captured.

Still, Charles had taught Louis that his hostility might be inconvenient. Louis saw his own advantage in entering upon a secret compact with Charles, which was studiously concealed from all but two of the king's ministers. Charles was to renew the French alliance against the Dutch. It was in the bargain that the French and English together should establish at the head of the Dutch government the young William of Orange (1650–1702), who was Charles's nephew. The office of stadtholder was not hereditary, though it had been held successively by members of the house of Orange ; the plan would, it was expected, give to the Dutch Republic a ruler who would be the puppet of his English uncle and his French patron. It was also a part of the bargain that Charles was to become the pensioner of Louis, and was to make an opportunity for restoring Roman Catholicism in England, wherein he was, if necessary, to be aided by French troops. The secret treaty of Dover, signed in 1670, prepared the way for the sudden declaration of war against the Dutch by England and France in 1672.

The scheme for the domination of the Dutch Republic by France with the assistance of England miscarried, however, because William of Orange declined to play the part assigned to him by his uncle and Louis XIV.

William of Orange

An internal revolution in the Netherlands resulted in the overthrow of the government and the murder of its leaders, the brothers De Witt. The victorious Orange party made William stadholder and captain-general. Thus, instead of securing a dependant, Louis had, by declaring war on the Dutch, acquired a bitter enemy. William unfalteringly fought every attempt at foreign aggression on Dutch soil. The Dutch, attacked at sea by both English and French fleets, fought desperately and successfully ; the military successes of the French were checked when William met the advance of their troops by opening the dykes and laying the country under water. Charles withdrew from the war, and Louis was left to fight alone. The outcome of the Dutch war was not the triumphant success anticipated by France, and Louis now found ranged against him Leopold, Roman Emperor, king of Hungary and Bohemia, and ruler of the Austrian duchies, who was temporarily relieved from the pressure of the Turkish advance which throughout this period repeatedly paralysed Austrian action in western Europe.

SIEGE OF LILLE IN THE WAR OF DEVOLUTION. This war, fought to gain certain Spanish territories in the Low Countries, was mainly a war of sieges. The illustration, from a drawing by Le Brun and Van Meulen, shows Louis XIV before Lille, which was forced to capitulate in 1667.

Treaty of Nijmegen

The campaigns of the ensuing years, conducted on the French side by Turenne and Condé, are of extreme interest to the military student, at least until Turenne's death in 1675. Even then the balance of success lay with the French arms, and the progress of the French navy was shown when it fought on equal terms with the Dutch, and held its own. By 1678 the allies were ready to make peace, in spite of the reluctance of William of Orange, and the treaty of Nijmegen resulted. Spain consented to give up Franche Comté, the Burgundian district which even Louis XI had been unable to seize 200 years before. In 1679 the French took Alsace from the Empire. Annexation of the free city of Strasbourg in 1681 gave France the key to south Germany and the strongest fortress on the upper Rhine. This was the zenith of Louis' career.

LESSON 8

Louis Quatorze: The Sun Sets

MEANWHILE, Colbert saw all his earlier hopes of great economic reforms vanishing. Vainly he endeavoured to keep money in the country, drawing up fresh plans for the creation of national industries; even in peace the king insisted on keeping a standing army of 120,000 men, and court expenditure was higher than ever. At the age of 64 Colbert died in 1683, worn out by hard work, much of which was wasted by the king's wars and lavish extravagance.

Although during the next ten years there was much diplomatic manoeuvring, active hostilities were not renewed until 1688. Much to the annoyance of Louis, Charles II tightened the English association with Holland by marrying his niece Mary, daughter of his brother James, Duke of York, his heir presumptive, to her first cousin, the stadtholder William of Orange. Then, in 1688, within four years of the death of Charles, came the revolution in England, the flight of James, and the joint accession of his elder daughter Mary, who was Protestant, and of her husband, as William III and Mary II.

Mme. DE MAINTENON was privately married to the king in 1684, after which she exercised much influence in the politics of France.

Immediately before that event, Louis had renewed the war. Louis' able military minister Louvois was always a powerful influence in the direction of aggression. Another similar influence was that of Madame de Maintenon, ultra-devout and fervent disciple of the Jesuits, to whom Louis was secretly married in 1684.

Anti-Protestant Influences

Mme de Maintenon encouraged Louis to reverse the religious policy of a century, and to persecute the Huguenots, a step which, before and after the Revocation of the Edict of Nantes, in 1685, caused a large body of the most industrious of the French population to emigrate to England, the Dutch Republic, and Brandenburg. Not only was Protestant sentiment violently aroused; the new policy met with no sympathy either from Austria or from the pope, the more because Louis, while posing as the champion of orthodoxy, was also claiming for the Crown supremacy over the Church in France. Thus Louis provoked widespread Protestant opposition without uniting the Catholics on his side.

During the middle of the reign (1661–1685) there was an outburst of literary greatness which enhanced the prestige of the court of Louis. The dramatists Molière, Corneille, and Racine, the fabulist La Fontaine, and the penetrating literary critic Boileau flourished at this time; but Molière's works—in particular his *Tartuffe*, that castigation of religious hypocrisy—would have been suppressed had they lacked royal support; Racine and Boileau were court historians; Corneille had a pension; Bossuet, the French bishop famous for the eloquence, sincerity, and strength of his preaching, was made court preacher. There is scarcely a name in the literature or art of the period that did not receive from Louis XIV some of the recognition that gives genius its chance. This literature was enjoyed by the educated upper class; the bulk of the people were illiterate.

If in 1685 Louis had gauged the situation more accurately he would have sought to preserve the English alliance. But he could not know that a revolution in England against James II was about to place his most determined antagonist on the throne of that kingdom. He began his new aggressive movement by an attack not on the Netherlands but on the Palatinate, which left William free to land in England and take possession of the throne upon his uncle's flight. Louis soon found himself fighting single-handed against a coalition of half Europe. After defeating the English fleet off Beachy Head, 1690, the French were masters of the Channel for nearly two years, until their navy, which Colbert had built up with such care, was shattered by the English off La Hogue in 1692. On land Louis' armies, brilliantly led, were nevertheless repeatedly checked by the stubborn defence of William of Orange, who, though he rarely won a victory, was always able to save his defeats in the field from developing into crushing disasters.

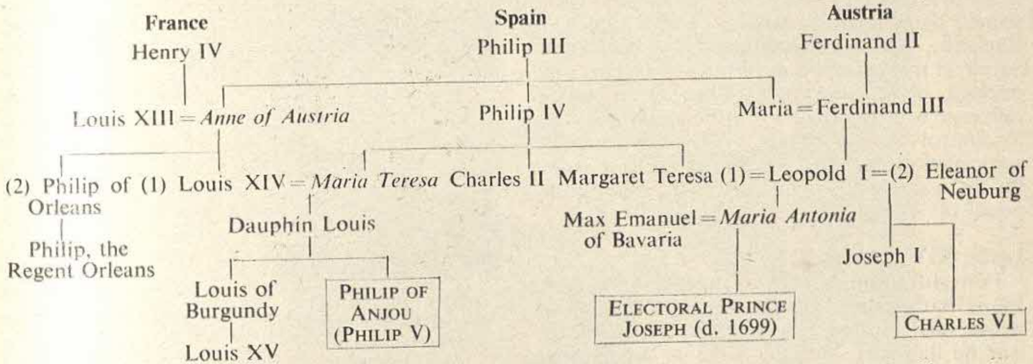
Check to French Aggression

Louis gained little ground, and the strain of the war was exhausting France. To all purposes she was bankrupt; in 1695 a graduated poll-tax was levied, but against growing financial chaos no such expedient was of any avail.

The war was brought to an end by the treaty of Ryswick in 1697. The Dutch Republic obtained some barrier fortresses within the Spanish Netherlands. England, never enthusiastic in the war, was satisfied by Louis' promise to recognize the Protestant succession. On the whole, the French position at the end of the war was worse than at the beginning.

The Spanish Succession

The check in no way served to curb Louis' ambitions. The question of the Spanish succession was assuming importance. The life of the feeble king Charles II, unexpectedly prolonged, was obviously near its end ; and he had no direct heir. No one in Europe could contemplate with equanimity the idea of the whole great Spanish dominion being attached either to France or to Austria, though the French king and the Emperor Leopold had been married respectively to the dying king's two sisters. Both the princesses had made a renunciation of title ; but the emperor himself had a claim through his mother, the eldest sister of Charles's father and predecessor, Philip IV.


France
Henry IV
Louis XIII = *Anne of Austria*
(2) Philip of Orleans
Philip, the Regent Orleans
(1) Louis XIV = *Maria Teresa*
Dauphin Louis
Louis of Burgundy
Louis XV
PHILIP OF ANJOU (PHILIP V)
Spain
Philip III
Philip IV
Charles II
Margaret Teresa (1) = Leopold I = (2) Eleanor of Neuburg
Max Emanuel of Bavaria = *Maria Antonia*
ELECTORAL PRINCE JOSEPH (d. 1699)
Austria
Ferdinand II
Maria = Ferdinand III
Joseph I
CHARLES VI

CLAIMANTS TO THE SPANISH THRONE. This table explains the genealogical relationships on which the French, Austrian, and Bavarian aspirants to the Spanish throne based their claims. The names of the princesses who resigned their rights to it upon marriage are given in italics, while those of the three claimants are in capital letters. Attempts at a partition were defeated by Louis XIV's acceptance of the Spanish king's will, leaving the entire inheritance to Philip of Anjou ; and war followed.

As matters stood, the Austrian succession would pass to Leopold's sons, the offspring of his second marriage. His Spanish wife had borne him a daughter, who had married Max Emanuel of Bavaria, to whom she had borne a child entitled the electoral prince. The compromise, therefore, which presented itself to Europe in general as the most satisfactory would recognize the electoral prince as the heir to the Spanish dominion, which would not thereby be directly attached to the reigning house of Austria, while the claims of that house through Leopold's mother, and those of Louis' offspring through his wife, would be met by dividing between them the Spanish possessions in Italy.

Upon these terms a partition treaty was arranged, to which all the principal powers were consenting parties. But this first partition treaty became waste paper when the young electoral prince died. In 1700 a fresh partition treaty was made. The claim of Max Emanuel of Bavaria to take his son's place was rejected ; William agreed with Louis to recognize the emperor's younger son Charles as the heir to the Spanish throne and to the Spanish Netherlands, and the younger grandson of Louis as heir to the Spanish dominions in Italy. Leopold was not satisfied with this second partition treaty. Charles II of Spain died in 1700 ; his will declared Philip of Anjou, the younger grandson of Louis, to be heir to the whole Spanish inheritance. Louis announced his intention of standing by King Charles's will.

For the moment it seemed likely that all opposition would be paralysed. Bitterly though William himself was opposed to the advancement of France, the peace party was dominant in both England and the Netherlands ; the English could not see that the question was of importance to them ; the Dutch were satisfied with their barrier fortresses. But Louis, with a strange unwisdom, broke up the peace party in both countries—in England by promising the exiled James II on his death-bed to recognize his son James Edward as the rightful king of England ; in the Netherlands by compelling the Dutch troops to evacuate the barrier fortresses.

The Grand Alliance

In both countries public opinion became zealous for war. William died early in 1702, but he lived long enough to organize the Grand Alliance against Louis, the principal allies being Austria, the Dutch Republic, and the United Kingdom.

The aggression and ambition of Louis XIV had created powerful enemies for France, and in the War of the Spanish Succession they combined to defeat and humiliate him. Spain's resources were under French control ; on the side of the Grand Alliance the maritime powers, the Dutch Republic and the United Kingdom, held command of the sea, while Austria possessed in Prince Eugene of Savoy (1663–1736) a general with a genius for the art of war, able to co-operate, when opportunity arose, with that equally great soldier Marlborough (1650–1722), who had been nominated by William III captain-general for both Dutch and English forces.

On William III's death, the Protestant Anne, second daughter of James II, became queen of England. She was dominated by her friend Sarah, at that time countess, but soon to become duchess, of Marlborough. Through his wife's influence over the queen Marlborough was able to control English policy. Although formerly associated rather with the Tories he now stood for the war party, which was in the main composed of Whigs.

Louis XIV's Allies

Powerful though the Grand Alliance was, Louis had certain advantages. In Spain his cause was popular. At the beginning of the war he had for allies the duke of Savoy, who controlled the north-western passes to Italy, and Max Emanuel of Bavaria, who was at feud with his father-in-law Leopold. The allies, on the other hand, were hampered by the fact that the Dutch cared for nothing except to keep the French armies out of their Republic, and that Dutch political commissioners exercised a disastrous authority over Marlborough, in nominal command of their armies. Organized co-operation between the Austrian forces under Prince Eugene and the Anglo-Dutch troops in the Netherlands was almost impossible. Marlborough was expressly forbidden to take any risks ; only his skill enabled him to translate his orders to stand on the defensive so as to manoeuvre the French back without a general engagement. In Italy, Eugene had for a time the better of his French opponents, till the overwhelming numbers of the enemy forced him to withdraw ; while in central Germany the French advanced.

PRINCE EUGENE of Savoy (1663–1736), in command of the imperial forces.

A great French campaign was planned for 1704. The French army from Alsace was to effect a junction with the Bavarians, advance on Vienna, force Austria into submission, and break up the coalition. The genius of Marlborough and Eugene completely foiled the scheme. While Eugene, retreating from Italy, joined the allied force which was watching the French in Alsace, Marlborough obtained permission to conduct a campaign on the Moselle which was sufficiently near home to satisfy the Dutch. But he had concerted his plans with Eugene. The Dutch suddenly learnt with horror that Marlborough and his army had disappeared ; they were racing up the Rhine valley to throw themselves between the French Grand Army and Vienna, while Eugene and the French Marshal Tallard were racing to the same point, with the Danube between them, the one to join Marlborough, the other to join the Grand Army.

DUKE OF MARLBOROUGH, victor of Blenheim, Ramillies, and Oudenarde.

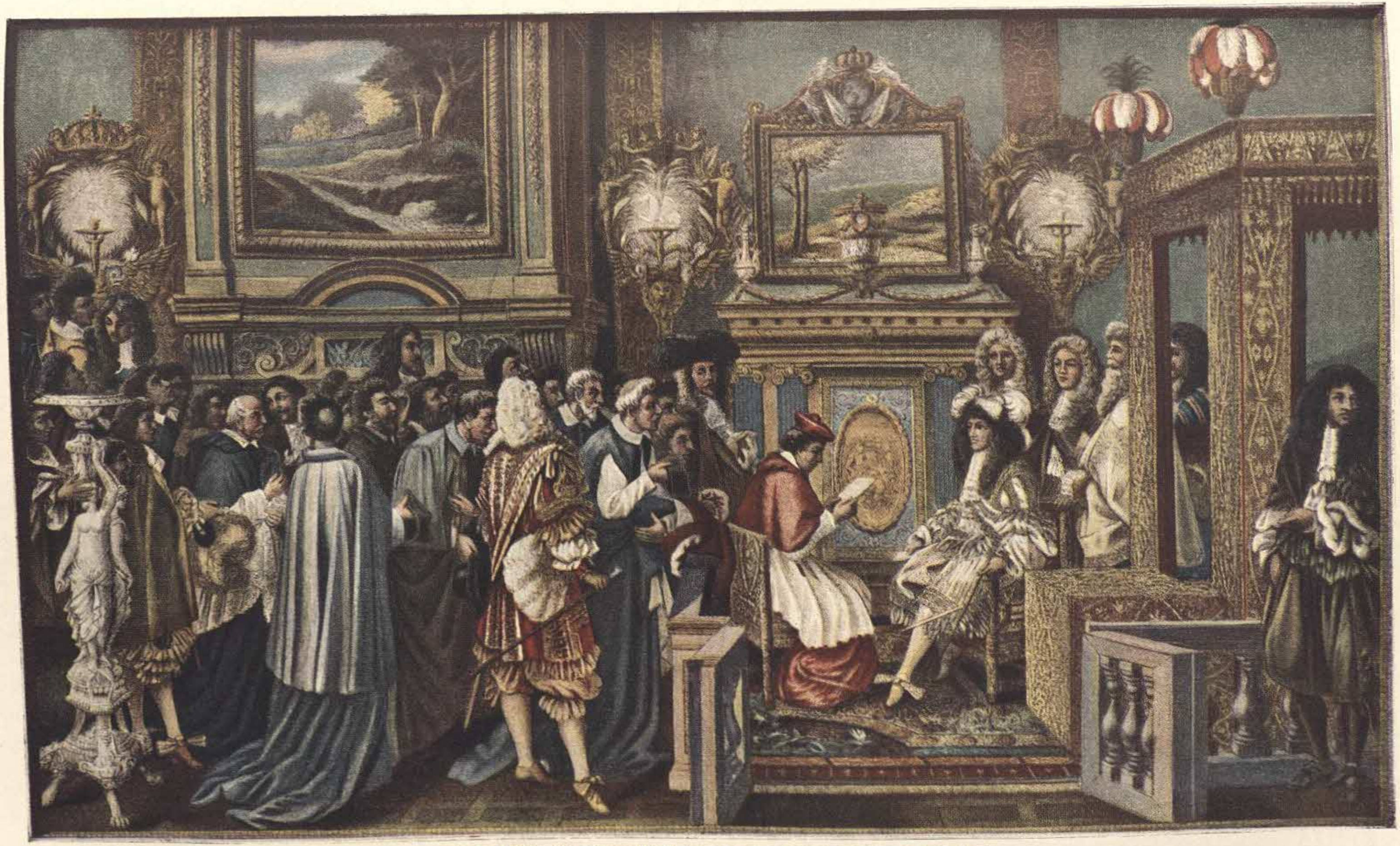
Then Marlborough struck what proved to be the decisive blow. The French and Bavarians met the English and Austrians at the battle of Blenheim, 1704, on the Danube. While Eugene kept the Bavarians and the French left hotly engaged, Marlborough successfully crossed the boggy ground which lay between him and the enemy's centre, the French right wing being engaged in beating off a fiery attack intended as a diversion. By a series of furious cavalry charges the French centre was broken, and the victorious troops rolled up the French left and annihilated their right. The victory was tremendous and decisive ; thousands were slain, thousands were taken prisoner. The rest of the French forces were scattered in flight, and throughout the rest of the war the French armies were kept behind the Rhine. Marlborough was back in the Netherlands before the French troops in that quarter had been able to take effective advantage of his absence.

About the same time, 1704, a combined English and Dutch naval force under Admiral Rooke surprised and captured Gibraltar, making it a British possession.

War Drags On

Two years later Marlborough won the victory of Ramillies, which was followed by the capture of a series of cities and fortresses in the Spanish Netherlands. Eugene, having re-organized the Austrian army, returned to Italy and drove the French out of that country. Savoy had changed sides, and Portugal had joined the Grand Alliance. In 1708 Eugene was able to join Marlborough, and help him to win his third great victory at Oudenarde.

France was becoming so exhausted, and Marlborough so apparently irresistible, that Louis was now prepared to submit to almost any terms. But when the allies required him, as a condition of peace, to employ his armies for the



DAZZLING SPLENDOUR OF THE COURT OF LOUIS XIV

The magnificence and elaborate ceremonial of the French court are displayed in this reproduction of a Gobelin tapestry designed by the court painter, Charles le Brun, and based on a painting by Antoine Mathieu. The scene represents an historical incident. The Duc de Créqui, French ambassador to the Papal court, had been insulted, and Pope Alexander VII sent his nephew, Sigismondo Chigi, to apologise to Louis. The audience was granted on July 29, 1664. The episode reveals the attitude of Louis to the Papacy. " Le Roi Soleil " was then 26, and had been effectively reigning since 1661.

suppression of his own grandson's supporters in Spain, he refused. The patriotic enthusiasm of the French enabled him to place another large army in the field. It was defeated at Malplaquet in 1709, but with greater loss of life to the victors than to the vanquished. Marlborough and Eugene were bent upon crushing France utterly. The allies continued to insist upon terms which it was impossible to accept ; Louis went on fighting. Public sentiment in England was already turning against the demands of the government. The fighting in Spain itself turned in favour of the French. A reaction of popular sentiment drove the Whigs from office and the duke from his command :· the Tories came in, determined to bring the war to a conclusion.

The death of the Emperor Joseph, who had succeeded Leopold in 1705, gave Austria, since he had daughters but no sons, to his brother, the archduke Charles, the Hapsburg claimant to the Spanish succession, who was also elected emperor as Charles VI. Thus the conditions under which the war began had become reversed. Europe could not possibly want one man to be Roman emperor, Austrian archduke, king of Hungary and Bohemia, lord of the Spanish Netherlands, of all that Spain held in Italy, of Spain itself, and of the Spanish empire in America. Since Charles would not resign his claims, the British government (England and Scotland had been administratively united in 1707) negotiated on its own account with Louis, kept its armies inactive, and in 1713 carried through the treaty of Utrecht. Charles, deserted by his allies, was shortly afterwards obliged to make his own treaty in accordance with the terms agreed to by France and Britain.

The treaty of Utrecht is a landmark in European history. There is no doubt that it left to Louis infinitely more than he would have dreamed even of asking after Oudenarde or Malplaquet. Nevertheless, it was a peace the terms of which would probably have satisfied William III. It left Louis' grandson Philip on the Spanish throne instead of a Hapsburg, though it transferred the Spanish Netherlands (henceforth called the Austrian Netherlands) to the Austrian house from which England and the Dutch Republic, whose barrier fortresses were secured to her, would have nothing to fear; and it left Louis Alsace. It secured to England Gibraltar and Minorca, possession of which meant British predominance in the Mediterranean.

A year later Anne was dead, and the elector of Hanover was seated on the British throne as King George I. In the next year Louis XIV died, leaving the crown to his great-grandson, Louis XV, a sickly child. If Philip V of Spain's abjuration of the French crown held good, the next in succession to the French throne was the regent, the Duke of Orleans, whose interests were, therefore, bound up with the maintenance of the treaty of Utrecht, which formally recognized the Hanoverian succession in Great Britain ; so that during the regency an alliance of the French government with the house of Hanover was effected.

The France of 1715 was thus less powerful externally, less prosperous, less united than the France of 1661. Louis XIV, despite his ambition, had in fact weakened his country.

LESSON 9

Decline and Rise of Four States

THE first half of the 17th century had been a time of inertia for the Ottoman power. In the second half it again became active, chiefly owing to a succession of very able grand viziers, the Kiuprili, a family of Albanian extraction ; and Turkish aggression threatened to be as dangerous as it had been at its zenith in the 16th century. In 1656, four years before Louis' accession, Mohammed, the first Kiuprili grand vizier, had been bent on reviving the conquering glories of Islam. In 1663, under his son Ahmed Kiuprili, the Turks were pouring into Austrian territory and threatening Vienna. They were routed at the battle of St. Gothard, where Leopold had the help of a French contingent. Louis Quatorze had been annoyed by an insult offered to his ambassador in Turkey ; he did not help Austria for the sake of Europe or the Church. But Leopold wanted only peace, and it was scarcely as a victor that he accepted the ensuing treaty (Vasvar, 1664). The Turks retained possession of Transylvania. From Venice they wrested the island of Crete. Then, in 1671, they attacked Poland.

Poland was a kingdom with an elective crown; but her kings usually exercised no real power ; the Polish nobles ruled the country so far as it was ruled at all. Nevertheless Poland was saved by King John Sobieski (1624–96), a shrewd statesman as well as a brilliant military commander, who secured the crown in 1674. He considered it his duty, apart from the menace to his country, to vanquish and slay the enemies of Christendom ; he also saw that the Turks were intent on conquering western as they had vanquished eastern Christendom two centuries before. It was boasted in Constantinople that the sultan would stable his horses in St. Peter's. In spite of the difficulties with which they had to contend, Sobieski's forces held the

Turks at bay, and routed them in one battle after another, until in 1676, having baffled the Turkish efforts to storm the Polish camps entrenched near the Dniester, Sobieski made a truce for five years and the Turks retreated from Poland.

Hungary, however, was restive under the rule of the emperor. The disaffected leaders allied themselves with the Turks, and in 1682 a Turkish army crossed the Danube. The king of France, who just then was not at war with Austria, exerted himself only to draw off any possible allies. Poland promised the emperor aid. In 1683 the Turks, under the grand vizier Kara Mustafa, invested Vienna. The besieged held out until the arrival of Sobieski and his army reinforced with a large contingent of Germans, when the Turks were utterly routed. The siege created such a stir and fear in Europe as had scarcely been known at the time of the Crusades. It lasted for 60 days, during which time the gay Viennese thronged their churches while Kara Mustafa camped outside with an army of 200,000 men, besides his harem, his eunuchs, and a large squad of executioners. The huge tents preserved in several South German museums give some idea of the splendour in which the Turks lived.

DESTROYER OF THE TURKS. The king of Poland, John Sobieski, a brilliant soldier, drove the Turks out of Poland and Hungary and routed a Turkish army besieging Vienna.

The emperor fled from the city before the siege began. When he returned he treated Sobieski coldly and with ingratitude: the foreign army in his capital was as unwelcome to him as Gustavus on the Rhine had been to Richelieu, once he had defeated France's enemies. The Poles were refused fodder for their horses and even had difficulty in getting decent burial for their dead.

Decline of the Turkish Empire

From that time the Turks were gradually driven back, though they still gained occasional successes. They were cleared out of Hungary and out of the greater part of Greece. Athens had been in Turkish possession since 1458. In 1687 the Venetians laid siege to the city. One of their shells fell upon the Parthenon, the most perfect specimen of Greek architecture (used by the Turks as a powder magazine), shattered the middle of the temple and destroyed the side columns. In 1697, Eugene, in command of the imperial armies, inflicted a great defeat upon the sultan himself at Zenta. At the same moment the Russian tsar, Peter the Great, was attacking the Turkish territories on the Black Sea. In 1699 the Turks accepted the peace of Carlowitz, which, in effect, made the Danube their boundary.

The last struggle took place when the War of the Spanish Succession had just terminated. Belgrade was captured by Eugene after a siege of two months. The treaty of Passarowitz, 1718, ended the Turkish war.

Austria secured Belgrade and part of Serbia (thus securing a foothold south of the Danube), the rich plains of Wallachia, part of Bosnia, and those parts of Hungary she did not already control. Declining Turkey secured the south of Greece from still more decadent Venice. The effect of this treaty was to make Turkey an easier prey and Austria (nearing the Black Sea) a rival to the power of Russia.

Creation of Prussia

The military power of Sweden was in abeyance after the death of Charles X in 1660, and the possessions acquired through the Thirty Years War were regarded greedily by the Danish monarchy and by Frederick William, the "Great Elector" of Brandenburg. The Great Elector limited the powers of provincial governments in his dominions, and strengthened that of the central authority.

He may be called the creator of the Berlin war office, which from its first days took the lion's share of the national income: the Elector wanted to be certain that he had the means

BESIEGER OF VIENNA. Kara Mustafa besieged Vienna in 1683, but his army was routed and the siege raised by Sobieski.

at hand to make war at any time. Meantime, he increased the national wealth by encouraging Huguenot refugees and Dutch farmers to settle on the poor Brandenburger soil. He extended his patronage to Jews and, though a stern Protestant, to Roman Catholics : the interests of the state made it worth his while to admit even those he disliked. Shrewd, hard-working, and autocratic, the Great Elector may well be reckoned as the founder of modern Germany. By dint of skilful and unscrupulous dodiplomacy he consolidated his scattered dominions which, under his son Frederick I, were converted into the kingdom of Prussia in 1701.

Peter the Great of Russia

By the beginning of the 16th century Russia was free of the Mongol supremacy, and was becoming united under a dynasty of which the most famous member was Ivan the Terrible (reigned 1547–84), the first Russian ruler to assume the title tsar. Russia was, however, a barbarian power, virtually cut off from communication with the civilization of the west, blocked from the Baltic Sea by territories over which ruled either Sweden or Poland. Until the reign of Peter the Great, who was tsar 1682–1725 (jointly with his brother Ivan 1682–96), Russia was of no account in the affairs of Europe.

Peter conceived the idea of remodelling the country on civilized lines. He was possessed of an indomitable will which shrank from no dangers and no difficulties. He meant Russia to take her place among the nations of the west. Within his own dominions he crushed all opposition with a merciless hand. He realized that Russian interests demanded access to the Black Sea and the Baltic, and the building of a fleet. If Russia was to be civilized, the process must be undertaken by someone who knew the ways of civilized countries.

CHARLES XII (1682–1718), king of Sweden. He soundly defeated Peter the Great at Narva, but was himself beaten at Poltava nine years later.

He travelled through Europe studying western civilization ; he laboured in Dutch and English dockyards studying shipbuilding. He went back to Russia, and set about training a disciplined army, chiefly under the direction of Scottish military adventurers. He abolished time-honoured customs, which he condemned as uncivilized. He captured Azov from the Turks, and began building his navy on the Black Sea. He conceived that the accession of a boy of 16, Charles XII, in Sweden, gave him his chance of acquiring Baltic territory, and he allied himself with Poland and Denmark with a view to the partition of Pomerania. By this time John Sobieski was dead, and the Poles had chosen Augustus of Saxony for their king. The Great Elector was also dead, and his son, Frederick, had not inherited his father's talents.

PETER THE GREAT (1672–1725), Russian tsar. Peter modernised the army and navy and founded a new capital, St. Petersburg.

In 1700 Poland had begun, and Denmark was on the point of beginning, an attack on Sweden, when Charles, who was now 18, seized control of Sweden by a *coup d'état*, compelled the rapid withdrawal of Denmark from the coalition, and then turned upon Augustus of Poland, who had attacked Riga, first putting to rout with his small body of troops a Russian horde gathered at Narva. Charles was a fighter, not a statesman. He thought of Saxony, not Russia, as the enemy. He overcame the Poles who, at his dictation, were quite ready to depose their Saxon king ; but Charles set the Polish nobility against him by selecting one of them, Stanislas Lecszinski, for the crown.

Defeat of Charles XII of Sweden

Augustus had to retire and to withdraw from the Russian alliance. But Peter was not disheartened by the rout of Narva ; on the contrary, his troops were again overrunning the Baltic provinces. Charles thought, like Napoleon after him, that he could conquer Russia by striking at Moscow. The Russians treated Charles as their descendants treated Napoleon. They avoided pitched battles, but when the Swedish forces had advanced far enough fell upon their line of communication. While Charles was laying siege to Poltava his isolated army was overwhelmed. Charles escaped into Turkey, where for a long time he endeavoured to bring on a war between Turkey and Russia. He succeeded ; but though the Turks had considerable success they contented themselves with a treaty by which they recovered Azov.

Meanwhile, all Pomerania was being absorbed by Charles's enemies. He hurried back from Turkey, but was too late to save his possessions ;

and in 1718 was killed by a stray shot while besieging the fortress of Fredrikshald in Norway. Charles died when only 36. He had won spectacular victories but his ceaseless wars brought Sweden to the verge of bankruptcy in men and money ; it is estimated that nearly one-third of her man-power had been lost, and the revenue amounted to only half the national expenditure. Through his tactlessness and Sweden's weakness he found a coalition of Russia, Prussia, Poland, Denmark, Hanover, and Saxony against him. Three years after his death the treaty of Nystadt added all Swedish possessions in the eastern Baltic to Russia ; nearly all those south of the Baltic were already lost to Prussia. Yet Swedes cherish the memory of Charles XII as Englishmen do that of Charles II and Scots that of " Prince Charlie."

From the moment of Charles's death Sweden fell permanently out of the group of first-class powers. Peter's activities for the rest of his reign were directed to the east, not the west.

LESSON 10

Spain Shows Her Weakness

AFTER the treaty of Utrecht, 1713, and the death of Louis XIV, 1715, although France was still the most powerful state in Europe, there was no further menace of a French dictatorship until the Revolution in the last years of the century.

The treaty marked the decisive defeat of the Grand Monarch's ambitious schemes, and the practical result was a re-arrangement of alliances. The French government, under the regent Orleans, required the friendship of Britain to secure it against the possible claims to succession of Philip V of Spain, uncle of the sickly young King Louis XV ; while in Britain the house of Hanover and the Whigs required the friendship of the French government, which otherwise might give its support to the exiled house of Stuart.

This association, however, was bound to disappear with the disappearance of the chance that the Spanish Bourbon might lay claim to the French throne if Louis XV died without leaving an heir of his body. A rapprochement between the two Bourbon dynasties would then be almost inevitable.

On the other hand, the immediately disturbing factor in European politics was to be found in the jealousies of Austria and Spain under her new dynasty, and the ambitions of Philip's queen-consort, the Italian Elizabeth Farnese, his second wife, for the advancement of her own children, whose succession to the Spanish throne was blocked by her step-children, the offspring of Philip's first marriage.

Elizabeth Farnese and Alberoni

At this time Spain was ruled by two of the cleverest heads in Europe : the queen and the prime minister, Cardinal Alberoni. Their failure to restore Spain to the rank of a first-class power is a sign of Spain's debility. Alberoni was said to be the son of a gardener in Parma. He was brought to Spain by the duke of Vendôme, and became Parma's representative at the Spanish court. Though a foreigner, he served Spain very well. It was he who

BATTLE OF CAPE PASSARO. On August 11, 1718, a British fleet commanded by Admiral George Byng defeated the newly created Spanish fleet that was blockading Messina. This battle ended Alberoni's hope to make Spain a great maritime power once again, for 25 out of 45 men-o'-war were either sunk or captured by British ships. This illustration is after a picture of the battle painted by Richard Paton.

brought over Elizabeth Farnese, daughter of the princely house of Parma : she was a good, although overbearing, wife to Philip, who had been moping since the death of his first wife. For nearly 30 years she scarcely ever left her husband's side—she ate, prayed, and worked with him—but her end in life was to advance not, like Alberoni, the interests of Spain but those of her children.

Defeat of Spanish Fleet

Philip V of Spain and Charles VI of Austria, who had become emperor in 1711, each considered that the treaty of Utrecht had robbed him for the benefit of the other. Alberoni's primary desire was the renovation of the Spanish maritime power, as well as the recovery for Spain of possessions which the recent treaties had conferred upon Austria or Savoy. Austria wished Savoy to exchange Sicily for Sardinia ; Alberoni wanted the same exchange to be made, as far as Savoy was concerned, but he wanted Sicily for Spain, not for Austria. His attempt to capture Sardinia was foiled by the intervention of France and Great Britain, each of whom was interested in maintaining the terms of the Utrecht treaty. Then, while Austria was engaged in her final struggle with the Turk, Alberoni attacked Sicily itself ; but his plans were frustrated by a British fleet which, under Admiral Byng, annihilated the newborn Spanish fleet off Cape Passaro. The capture of Belgrade by Eugene released masses of Austrian troops, the Spanish attempt to recover power failed completely, and the other powers united in compelling Philip to dismiss his minister.

Within the next few years Robert Walpole (1676–1745) was firmly established at the helm in Great Britain ; the regent Orleans died, and Louis XV placed Cardinal Fleury (1653–1743) in control of affairs in France. Also, Louis' marriage to the daughter of Stanislas Lecszinski (who had again been turned out of his Polish kingdom by Augustus of Saxony), and the birth of a son four years later, made it improbable that the opportunity would ever occur for Philip of Spain to lay claim to the French throne. From this time it was Fleury's object to establish that intimate association between France and Spain at which Louis XIV had aimed in the War of the Spanish Succession. By 1733 this policy had issued in the secret family compact of the two Bourbon powers, directed, in the first place, against Austria and, in the second, against Great Britain.

British and French Diplomacy

Both Walpole and Fleury wanted to achieve their ends not by fighting but by diplomacy. Walpole wanted to secure a material prosperity which would keep the British contented with the Hanoverian dynasty, while material wealth acquired through commerce would also in the long run carry with it fighting power. Fleury wished France to recuperate after the financial exhaustion consequent upon the wars of Louis XIV. For the time, therefore, Fleury and Walpole could act in concert, though Fleury's secret policy was an ultimate menace to Great Britain, and Walpole was perfectly aware of the fact. But neither statesman made preparations for such a struggle. Fleury, relying on diplomacy to keep Austria and Great Britain apart until Austria should be too much weakened and too resentful towards her old ally to join forces with her, made no attempt to resuscitate the Franco-Spanish navies for a contest with the British navy ; Walpole paid no attention to naval or military organization, and until 1739 he kept his country at peace.

LESSON 11

Wars of the Polish and Austrian Successions

EUROPE plunged into the War of the Polish Succession in 1733. Russia wanted the second Augustus of Saxony to succeed his father on the Polish throne ; France wanted the succession for Stanislas Lecszinski, the French king's father-in-law—a "shuttlecock king," who played an undignified part in the vicissitudes of Poland. The quarrel might have been patched up without a European war but for the Emperor Charles VI, who wanted the Austrian succession to go after him to his daughter Maria Teresa (although if a female succession was accepted his elder brother's daughter might be considered to have a better claim). Charles wanted the support of the elector of Saxony for the instrument called the "Pragmatic Sanction," in which he declared that his daughter was his heiress, and for which he had procured the guarantee of most of the powers. Therefore he supported the elector of Saxony's claim to the Polish succession in opposition to France ; whereupon France and Spain turned the struggle into one in which Italian territories were of more importance than the actual Polish succession. Walpole looked on while half the European powers were draining their treasures and exhausting their armies.

The outcome of the War of the Polish Succession was that, while Augustus of Saxony got Poland, Naples was made into a kingdom for a third Spanish Bourbon prince, and France strengthened her own position by persuading

THE EMPEROR CHARLES VI (1685–1740), who by the "Pragmatic Sanction" declared his daughter his successor in Austria.

Francis, husband of Maria Teresa, to exchange his dukedom of Lorraine for Tuscany. Lorraine, given to Stanislas for life, was to revert to France on his death, which happened in 1766. Austria, though she lost Naples and Sicily, acquired the greater part of north Italy. The exchange of the island of Sicily for Sardinia by the duke of Savoy, who was now king of Sardinia, had been accomplished some time before.

War of Jenkins's Ear

The Bourbons, then, had gained a good deal, though it was at the price of an exhausting war. But Austria was not yet materially weakened. Naturally, the opportunity for carrying out the objects of the family compact would have come with the death of the emperor Charles VI, which took place in 1740, and the inevitable struggle for the Austrian succession which followed. But, in the first place, the programme was spoilt, not by the statesmen but by a violent outburst of popular feeling in England and in Spain, which forced the hands of the politicians and plunged those two countries into a war on their own account, called the War of Jenkins's Ear because one of its contributory causes was the alleged cutting off of a Captain Jenkins's ear by a Spanish naval officer in 1731. And when Charles died all previous calculations were upset by the unexpected action of Frederick II of Prussia.

After Peter the Great died in 1725 Russian conditions deteriorated grievously. The bureaucracy which he had "created to be the servant of the country, made the country its servant ; the army . . . he created to be at the disposal of the throne, had the throne at its disposal." Five years later the Russian crown was secured by Peter's niece, Anne of Courland, who for ten years maintained her absolute authority ; but, apart from the intrigues of the court and palace plots, she was principally engaged in indecisive conflict with the Turks. She died in 1740, and in 1741 the succession was secured by Peter's daughter Elizabeth, the ruler of Russia for 20 years to come. Before her accession she was an indolent woman of abandoned tastes ; as empress she ruled with energetic ability and strengthened Russian influence in Europe.

Growth of Prussia

After the death of the Great Elector of Brandenburg his son Frederick did little enough to extend the power of his principality, but he had been permitted to assume the royal title as King Frederick I of Prussia. Frederick's son, Frederick William, had devoted himself entirely to the organization of his kingdom as the basis of an army. He built up a highly efficient military machine. His son, Frederick II, called the Great, who succeeded him in 1740, was determined to use that military machine for the consolidation of his kingdom by the acquisition of sundry territories which were strategically necessary to its political development. Prussia was still separated from Brandenburg by a wedge of Polish territory stretching up to the shores of the Baltic. Silesia, which lay within the Austrian dominion, was necessary to the completion of the kingdom Frederick contemplated, and he had some sort of technical claim to it, based on a political bargain made by his great-grandfather, the Great Elector. At the end of 1740 Maria Teresa (1717–80) claimed the succession to Austria, Bohemia, and Hungary and their dependent territories in accordance with the Pragmatic Sanction.

The British and the Spaniards were already fighting each other. British merchantmen, in

JENKINS'S EAR. The Anglo-Spanish War of 1739 is often called the "War of Jenkins's Ear," for a contributary cause was the alleged cutting off by a Spanish naval officer of the ear of Robert Jenkins, a merchant sea-captain. This caricature shows the captain proffering his severed ear to Walpole.

spite of the trade privileges acquired by the treaty of Utrecht, persisted in evading the restrictive regulations on that trade, and the Spaniards persisted in enforcing those regulations in a high-handed and often illegal fashion. Walpole, though favouring a policy of peace, had been compelled to yield to the storm of popular wrath, and had declared war. Charles of Bavaria, in right of his wife, daughter of Charles VI's elder brother, claimed Charles VI's personal inheritance. He was also the successful candidate for the imperial crown. France and Spain had no sort of intention of standing by their guarantee of the Pragmatic Sanction. George II of England, as elector of Hanover, was entirely on the side of Maria Teresa.

At this point the king of Prussia, upsetting all the calculations of Fleury and Walpole, advanced into Silesia, and announced to Maria Teresa that if she would acknowledge his sovereignty in that province he would stand by her. In 1741 he proved his own importance and the value of his troops by winning the battle of Mollwitz over the Austrians, the queen having naturally repudiated his proposals. France intervened, sending her troops as auxiliaries for Bavaria; and though Great Britain sent troops to help Maria Teresa, theoretically Great Britain and France were not at war with each other.

George's position made him anxious to remove the Prussian menace to Hanover by persuading Maria Teresa to buy Frederick II off with a substantial portion of Silesia. In fact, she found her position so critical that, although the usually turbulent Hungarians proclaimed their enthusiastic support of her cause, she did for a time neutralise Frederick by ceding Lower Silesia; later he obtained more.

MARIA TERESA, archduchess of Austria, queen of Hungary, and wife of the Emperor Francis I.

Each of the belligerent states was seeking some gain for itself, so that neither of the coalitions worked in real co-operation. In 1744 the tide had so far set in favour of Maria Teresa that she was disinclined for peace, except on terms by which she would recover what she had been obliged to give up. George's efforts to procure a pacification failed, new leagues were formed, and France entered the war, no longer as an auxiliary but as a principal, so that at last the governments of Britain and France were actually formally at war—a circumstance deriving special importance from the fact that it opened the way, hitherto closed, for the French and British East India Companies to attack each other in India.

In 1745 the emperor Charles VII (Charles of Bavaria) died. His son Maurice did not maintain his father's claims against Maria Teresa, nor was he a candidate for the imperial crown. With his support Maria Teresa's husband Francis was elected emperor. France was prospering in the Austrian Netherlands, and Frederick would give up nothing of what he had gained. Since Prussia and France could not come to terms with Maria, the war went on.

For Great Britain, interest in 1745 was varied by the Jacobite insurrection headed by Charles Edward Stuart, the Young Pretender. Charles led his Highlanders into the heart of England, but his advisers refused to advance farther than a spot south of Repton near Derby.

The prince was compelled to retreat, and in the next year the hopes of the Stuarts were finally blasted by the decisive victory of the Hanoverian government forces at Culloden.

FREDERICK the Great, king of Prussia, 1740-86, Maria Teresa's chief enemy.

A pacific king, Ferdinand, succeeded to the Spanish throne. He at once sought to withdraw from the war. Frederick also held his hand. In the course of the war Britain had proved her decisive superiority at sea. French and British had been fighting in America, where the British had taken Louisburg, which lies just outside the mouth of the St. Lawrence. They had been fighting in India, where the French had turned the British out of Madras. But all the parties were tired of a struggle which seemed to promise a result satisfactory to none.

Peace of Aix-la-Chapelle

The War of the Austrian Succession was brought to an end in 1748 by the peace of Aix-la-Chapelle. The one solid gainer was Frederick of Prussia, who retained Silesia. Maria Teresa and her husband were recognized as rulers of her father's heritable lands (except Silesia) and of the Holy Roman Empire. The other combatants for the most part retained such conquests as they happened to have made. Louis XV gave up his conquests in Italy and the Austrian Netherlands, and lost the popularity he had enjoyed earlier in his reign. The war had done nothing beyond proving the ascendancy of the British fleet on the seas and the military power of Prussia.

LESSON 12

The Seven Years War

At the beginning of 1756 the Austrian league was all but completed ; in May France and Austria signed a defensive alliance. The alliance between Prussia and Britain (which involved Hanover) was ensured by the defensive treaty of Westminster in January of that year ; while it was certain that Saxony, lying on the southern frontier of Brandenburg, would act with the powers which were bent on crushing Frederick. War started again in Europe in the same year when the French attacked and captured Port Mahon, in Minorca. The next blow was struck by Frederick, who suddenly marched into Saxony, hoping to force it into immediate submission, and, when he had paralysed it, to fling himself upon Bohemia before the Austrians were ready. Saxony offered a more stubborn resistance than he had anticipated, and he was not able to advance against Austria until the following year, 1757. For nearly a year Britain, under an incompetent administration, accomplished nothing. Then the control passed to William Pitt.

From the moment of Pitt's ascendancy the war took on a definite character. Pitt threw his energies into vigorous development of a naval policy which was to secure not merely an ascendancy at sea but very nearly a monopoly of sea power. He planned and organized campaigns in America, to be supported by the fleet, which should destroy the French power in Canada. He made it impossible for French reinforcements to reach India. By perpetually threatening a descent upon the French coast he compelled France to retain large defensive forces at various points, instead of concentrating armies for the overwhelming of Prussia. Only small contingents were sent to aid the Prussian army, which covered the west of Brandenburg from attack, but large subsidies were poured into the treasury of the Prussian king. Pitt's contribution to the war on the Continent materially helped Frederick to maintain the contest against an increasing number of foes.

Capture of Quebec

In North America the French and British colonists had been fighting for two years before war was actually declared. Pitt's plan of crushing the French in Canada by converging columns was at first foiled by the incapacity of the British commanders. The British fleets, however, prevented the French from receiving effective reinforcements. The key of the French position in Canada was Quebec. In 1759 Quebec was captured by a brilliant feat of arms, the scaling of the Heights of Abraham, by General Wolfe, and the routing of the French forces under Montcalm on the summit ; Wolfe was killed, Montcalm mortally wounded, in the action. The fall of Quebec was followed by the fall of Montreal, and the conquest of Canada was virtually completed. In the same year the British fleet annihilated the French navy by the victories of Boscawen at Lagos and Hawke at Quiberon Bay.

Campaigns of Frederick the Great

Meanwhile Frederick had been carrying on his amazing struggle against the united powers. The one advantage he possessed was that of occupying the central position, from which he could strike with extreme rapidity at one point after another of the enclosing circle. In 1757, while his enemies were slowly moving up on every side, he dashed upon Prague with his main force, won a great victory there and, when the great Austrian army, much larger than his own, was brought on the scene, lost what he had won in a disastrous defeat at Kolin. However, he managed to retreat through Saxony, unpursued by the slow-moving Austrian commander Daun.

By this time a French army was moving up from the south under Soubise ; Frederick, with his re-organized forces, shattered it at Rossbach. Within a few weeks he was in Silesia again, and won a victory over the Austrians at Leuthen. In 1758 the Russians

CAPTURE OF QUEBEC, 1759. A contemporary print showing British ships moving up the St. Lawrence. The assault on Quebec was carried out at night, Wolfe and his men approaching in boats with muffled oars and scaling the cliff under cover of darkness.

advanced against him ; he checked them in a desperate battle at Zorndorf and then had to hurry back to Saxony, where, in spite of a defeat at Hochkirchen, he succeeded in forcing Daun to fall back to Bohemia. The frightful casualties suffered in these pitched battles had reduced his Prussian forces to very small numbers, but in 1759 Frederick was saved by a decisive defeat of the French by Ferdinand of Brunswick, in command of the British, Hanoverian, and Brunswicker army at Minden in Westphalia. On the other hand, the Russians inflicted a severe defeat upon Frederick at Künersdorf. If the victors had followed up their advantage, the fate of Prussia must have been sealed. In 1760 the exhaustion of Prussia was still more marked ; but while the means of sustaining and destroying life remained Frederick was determined to continue.

FREDERICK II AND HIS ARMY. This illustration, after Chodowiecki, shows "Old Fritz" reviewing his troops at Potsdam. Behind him is his nephew, afterwards King Frederick William II.

Two events then changed the affairs of Europe : the resignation of Pitt from office and the death of the tsarina Elizabeth of Russia. Pitt's successor, Bute, arranged the peace of Paris, followed by that of Hubertusburg, in 1763, and Russian hostility ceased or was suspended. France was exhausted by the struggle with Britain, whose armies and fleets had captured many of the overseas possessions of France and some of those of Spain, which had been induced to join in a hopeless conflict. The broad outcome of the Seven Years War was that the English East India Company was established as a territorial power in India, where France no longer had any effective foothold. Canada was ceded to Great Britain, which, by the treaty, resigned a good many conquests. In Europe there were no territorial re-arrangements, but Frederick remained in possession of Silesia. The Prussian kingdom had taken its place among the Great Powers of Europe.

LESSON 13

Birth of the U.S.A.

A long interval was to elapse before there was another European war. France, Austria, and Prussia, at the moment, found sufficient scope for their energies in devoting themselves, with more or less success, to recuperation after the exhaustion of the Seven Years War. Russia continued under Catherine the Great (tsarina 1762–96) the process of consolidation and expansion southwards and eastwards begun under Peter the Great.

Partitions of Poland

For a long time past, however, the three eastern powers—Prussia, Russia, and Austria—had turned greedy eyes upon Poland. Russia wanted the eastern provinces of that kingdom, Austria those on the south, while Frederick wanted West Prussia, the Polish province which isolated his own dominion of East Prussia by cutting it off from Brandenburg. In 1772 a first partition robbed Poland of a third of its people and a seventh of its territory. Austria took Galicia on the south, Prussia the West Prussian region, and Russia a part of Lithuania. Two further partitions in 1793 and 1795 obliterated Poland. Neither Great Britain nor France intervened.

When Frederick the Great died in 1786, he had raised Prussia, by the diplomacy of his latter years almost as much as by his wars in the past, to be the premier power in Germany. This he accomplished by posing as the champion of the rights of the German princes in the face of the unconstitutional efforts of the emperor Joseph II, son of Maria Teresa and the emperor Francis I, to establish an effective imperial control : Joseph was a man of lofty but confused ideals, conspicuous as one of the "enlightened despots" of the period, but unfortunate in his drastic reforms—he was ahead of his times and too revolutionary for his conservative subjects. Frederick was succeeded by his colourless nephew, Frederick William II.

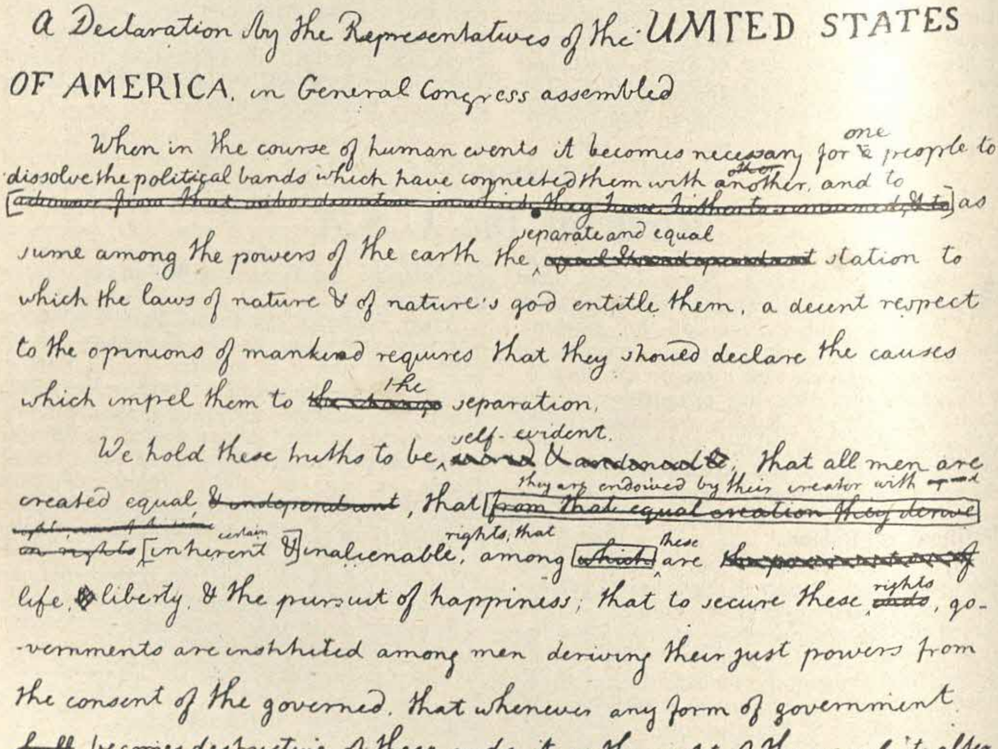
War of American Independence

In its influence on world history, the supreme event of this period was the birth of the Republic of the United States of North America. The Seven Years War, which ended in 1763, had left Great Britain with a heavy debt ; and it was the efforts of the government in London to collect from the colonies some of the cost of the English army in America that led to the revolt.

George WASHINGTON (1732–99), C.-in-C. of the American colonists in the War of Independence, first U.S. president 1789–97.

In 1765 parliament passed a Stamp Act, imposing a stamp duty on certain business documents. So violent was the reaction that it was repealed in 1767; but repeal was accompanied by a declaratory act asserting the right of parliament to pass laws which should bind the colonies. In America was raised the cry, "No taxation without representation." There was abstract justice in the demand that the colonies should share the burden of cost of imperial defence, but the ministers of George III unwisely pushed the matter to extremes. Sam Adams, propagandist, and James Otis, lawyer patriot, fomented separatist feeling by their speeches, pamphlets, and state papers. New taxes were imposed by the government in England. In 1773 occurred the celebrated "Boston Tea Party," as a result of which other repressive measures were passed. The "tea party" had consisted of the throwing overboard by Bostonians disguised as Red Indians of £10,000 worth of tea, which was liable to duty. The colonists took up arms to maintain their rights in 1775, still declaring themselves loyal to the British connexion. When once war had begun, the colonists dropped the theory of loyalty, and, inspired by Benjamin Franklin and Thomas Jefferson, issued their Declaration of Independence on July 4, 1776. With indomit-

Thomas JEFFERSON (1743–1826), helped frame the Declaration of Independence, was president of the U.S.A. 1801–09.



a Declaration by the Representatives of the UNITED STATES OF AMERICA, in General Congress assembled

When in the course of human events it becomes necessary for ~~a~~ one people to dissolve the political bands which have connected them with other another, and to [~~advance from that subordination in which they have hitherto remained, & to~~] assume among the powers of the earth the separate and equal ~~equal & independent~~ station to which the laws of nature & of nature's god entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to ~~the change~~ the separation.

We hold these truths to be self-evident ~~sacred & undeniable~~; that all men are created equal, ~~& independent~~, that they are endowed by their creator with ~~equal~~ [~~from that equal creation they derive~~] ~~[illegible]~~ ~~in rights~~ certain [inherent &] inalienable rights; that among [~~which~~] these are ~~the preservation of~~ life, ~~&~~ liberty, & the pursuit of happiness; that to secure these rights ~~ends~~, governments are instituted among men deriving their just powers from the consent of the governed; that whenever any form of government ~~shall~~ becomes destructive of these ends, it is the right of the people to alter

Patent Office, Washington

DRAFT OF THE DECLARATION OF AMERICAN INDEPENDENCE. On July 4, 1776, the 13 North American states in congress adopted the Declaration of Independence.

able patience and perseverance their leader, George Washington, succeeded in keeping the colonial armies under his command from dissolving, while Thomas Paine, an English journalist, kept up their morale by expositions of the American case particularly in a pamphlet, *Common Sense*.

The British operations were conducted without intelligence or vigour, probably in the expectation that the colonial resistance would presently collapse of itself. Instead of collapsing, the colonists ruined the British plan of campaign in 1777 by trapping a British force at Saratoga and compelling it to capitulate. The French saw their opportunity, and allied themselves with the rebellious colonists whose armies were reinforced by French volunteers. French fleets sailed to the West Indies—France had realized that, to fight the British power, a great fleet was essential—and it was the presence of a French fleet which compelled the surrender of the British commander, Cornwallis, at Yorktown, the blow which destroyed all prospects of a British victory.

Thomas PAINE (1737–1809), British pamphleteer, a supporter of the American colonists' cause.

Spain joined with France, but Spanish energies were mainly devoted to a vain attempt to capture Gibraltar, which stubbornly defied her utmost efforts. When a Spanish fleet attempted to join the French fleet in the West Indies it seemed as though Britain's maritime power would be annihilated, but before the junction could be effected the British admiral, Rodney, destroyed the French fleet at the battle of The Saints. British naval supremacy was saved; but the peace of Paris, negotiated in 1783, recognized the independence of the British American colonies south of Canada, where the French had been conciliated by wise government.

Benjamin FRANKLIN (1706–90), scientist and writer, who gained French support for the colonists.

The full story of Britain's acquisition of paramount influence in the Indian peninsula is told in the Course *British History*, but it should be noted here that, while the future United States of America was cutting itself loose from the British Empire, in India the British position was being consolidated, mainly by the genius of the first governor-general, Warren Hastings (1732–1818), a man of great qualities. By actions which were often high-handed, and by some which could be excused only because the alternative would have been the disappearance of the British from India, Hastings succeeded in maintaining authority.

As yet only a fragment of India was under direct British control. Before Hastings left India in 1785 the younger Pitt had passed in England the India Act, which re-organized the government of the East India Company's possessions in India, and placed ultimate control in the hands of a government committee in London, directly responsible to parliament; the general control in the hands of the company in London; and the practical management of affairs in the hands of the governor-general with his council on the spot.

LESSON 14

The French Revolution

The French Revolution was a revolt against the social order which was universal in Europe, and in France was stronger than anywhere else—the order which divided the world socially and politically into classes separated from each other by almost insuperable barriers, affording to a small group of favoured persons exemptions, privileges, and authority; to the rest of the community burdens, disabilities, and subjection.

Like the Reformation, it was a rebellion against authority conventionally accepted for centuries; but now it was the political rather than the religious authority that was called into question. For feudalism, as it disintegrated, Europe had substituted absolute monarchy, supported by an aristocracy which was bound up with it.

England had led the way by blotting out of her system the theory of the divine authority of monarchs, and had substituted in diverse forms the conception of something in the nature of a contract between the Crown and the people—a theory that the government must in some sort express the popular will, that the monarch's right to rule depended, in effect, on his agreement with the popular will. In other European countries, however, the monarchical theory still ran on the lines that the monarch was divinely appointed to rule; that he was bound, as God's vicegerent, to rule righteously and to act as the father of his people, but that if he neglected to do so he was within his rights as far as his subjects were concerned and was accountable to no one but his Creator.

On the whole, the leading monarchs of Europe were inclined to be benevolent despots, though their benevolence was mitigated by a great sensitiveness where their own interests were concerned. Upon these theories were impinging novel humanitarian notions concerning the "rights of man," urgent beliefs that man in his natural, unsophisticated condition was a much nobler creature than man misshapen by social pressure. The somewhat arid doctrines of the Whig philosophers in England were taking a new emotional shape—in effect, a demand for the restoration of the social contract to the supposed original form out of which it had been distorted by the rich and powerful till it had become merely an instrument for their own convenience.

Three Estates of France

Very much more than in England, the great bulk of the population in the countries of Europe suffered from practical grievances. In France the noblesse and the clergy were almost exempt from taxation, of which the burden was borne by the bourgeoisie and the peasantry. In England the law recognized no distinction between classes, however rigidly such social distinction might be enforced by custom. In France the law emphasised such distinctions. Society was divided into three estates: the clergy, the nobility, and a third estate composed of the bourgeoisie or established citizens (merchants, manufacturers, and professional men), the artisans, and the peasants. Although many of the bourgeoisie were wealthy they were subjected to hampering restrictions, and thus had their own grounds for discontent.

LOUIS XVI (1754–93), king of France, 1774–92. He was charged with treason against the republic and guillotined, Jan. 21, 1793.

The artisans were a large class, whose products went all over the world. Some were independent workers, turning their cottages into workshops in which the whole family slaved for a bare living. They bought their raw materials from a middleman and sold the products to the same or another middleman. Other artisans worked in the factories which were either "royal"—that is, run by shareholders enjoying privileges under a royal charter—or private concerns without privileges. In the royal factories the workers were signed on for, and guaranteed, four years' service, but were subject to fines, a 12-hour day, and restricted liberty. The artisans in the free factories were more independent, but were subject to unemployment and fluctuating wages as demands on the labour market fluctuated.

MARIE ANTOINETTE (1755–93), daughter of Maria Teresa, married Louis XVI in 1770. The unfortunate queen was executed, Oct. 16, 1793.

The peasantry living directly on the produce of the soil formed the bulk of the population. They held their land from overlords, the rentals complicated by feudal tenures, forced labour conditions, and the burden of unfair taxation. Some were miserably poor; others, the peasant farmers, were disgusted at the lack of correspondence between economic realities and the legal forms that imposed on them obligations of a dead social system.

Besides the arbitrary distinctions of class, there were at least three other causes of profound discontent under the "ancien régime": anomalies in the public administration, in the law, and in commercial and industrial affairs. But the supreme immediate grievance lay in the grinding poverty of the poor, and the complete financial chaos produced by the interminable wars for generations past. The natural and immediate remedy lay in a readjustment of the burdens of taxation which should diminish the extortions from the poor and compel the rich and powerful to pay their share; but fundamentally any change must carry with it the principle that the mass of the people should have a voice in the government.

Louis XVI and the States-General

The revolution may be said to have begun when Louis XVI, an amiable monarch with the best intentions, but somewhat lacking in intelligence, was persuaded to revive an institution which had dropped out of use for the best part of two centuries, and to summon in 1789 the States-General—a sort of parliament of the three estates—which was to undertake the task of reconstruction. The noblesse and the clergy, or at any rate the higher clergy, did not want reconstruction. The assembly of the third estate (the commons) succeeded in carrying the principle that the three estates should vote together—whereby the third estate obtained preponderance—instead of in three separate chambers, which would have ensured that the two privileged chambers, acting in concert, would outvote the third.

This composite chamber called itself the national assembly. Among its first decrees were those abolishing the censorship. The press, thus released, exerted a great influence until it was again censored under Napoleon.

Fall of the Bastille

When it appeared that the government intended to pay no serious attention to the assembly thus constituted, a volunteer force, called the National Guard, was enrolled and the Parisian populace found little restriction on its freedom to do what it liked so long as the National Guard was on its side. The people marched on the Bastille, the fortress-prison which was the material symbol of arbitrary rule, stormed it, and destroyed it, July 14, 1789.

Force was on the side of the national assembly, which proceeded to enact the abolition of one after another of the privileges of the noblesse and the clergy, including the abolition of feudal rights and the suppression of religious orders. The Church was dispossessed of all property and tithes were withdrawn. Many of the aristocrats made haste to escape out of the country. The national assembly found that it was not, like English parliaments, modifying and defining, securing what it conceived to be the historical principles of the constitution ; it was, on the contrary, abolishing the base on which the whole constitution was built up. It was necessary to create from the beginning a new constitution to take the place of that which was being destroyed.

When the Comte de Mirabeau, whom the noblesse of Provence, his native province, had rejected, appeared in the chamber of the estates on May 5, 1789, as a representative of the third estate, he was well known for the scandals he had created by duels, love affairs, quarrels with his father, lawsuits, and imprisonments ; his genius as an orator, pamphleteer, and political organizer was not suspected. During the early months of the Revolution, as leader of the third estate, he opposed with great force—from June to October 1789—the privileged classes and the court. Mirabeau, always in the centre of the stage, became the head of an intelligence department. Over against the royal ministry, he secured acceptance, by sheer force of his powerful personality, of what was really a ministry although it had neither legal authority nor title.

Mirabeau tried to enter into negotiations with the Marquis de Lafayette, the commander of the Parisian National Guard, himself a firm believer in reform, though a moderate and devoted to the royal family. But at the critical hour, when Lafayette might perhaps have persuaded the court to summon himself and Mirabeau, the constituent assembly took alarm, and, fearing to lose its newly found authority, voted the decree of November 7, excluding from the royal ministry all members of the assembly—Mirabeau in particular. For the next two years—until his death in 1791—he devoted himself to the fulfilment of his forlorn hope : reconciliation between king and nation for the common weal.

King's Flight to Varennes

Lafayette had been powerless to prevent the populace of Paris from rushing upon the château of Versailles. All he could do was to save the king and queen—beautiful, brave, extravagant, dignified Marie Antoinette—who

STORMING OF THE BASTILLE. On July 14, 1789, the people of Paris rose, stormed the Bastille and razed it to the ground. This prison fortress represented the king's autocracy to the frenzied mob, while its fall stood for the collapse of the hated " ancien régime." This picture is from a drawing by Prieur.

were brought back to the Tuileries by the crowd. Afterwards, in spite of his devotion, Lafayette was unable to be of assistance to the queen, because he was shorn of the authority necessary to keep law and order. The flight of the king to Varennes, June 21, 1791, in which Lafayette was a responsible agent, and the killing of citizens, at the Champ de Mars, who protested against the refusal of the assembly to proclaim the deposition of Louis, lost Lafayette his popularity. He withdrew temporarily from politics; and after his failure to stem the violence of the Jacobins (the extreme revolutionary party) in 1792, rode into the neutral territory of Liège and was seized and imprisoned by the Austrians.

The king, after the abortive attempt to escape from the country—he was recognized at Varennes with his wife and children and brought back to Paris—had perforce to accept the new constitution, September 1791, and the government was vested in a legislative assembly, from which the members of the old national assembly had excluded themselves by a self-denying ordinance. The new assembly therefore contained none of the real leaders of the party of revolution, and its members were wholly inexperienced in the conduct of affairs of state. The old extremists found a field for themselves in the Commune, or government of Paris.

War with Austria

Meanwhile the émigrés, the aristocrats who had made their escape from the country, were clamouring for foreign intervention, and calling upon the monarchs of Europe to restore by force the old monarchical order. The emperor Leopold (the French queen's brother) and the king of Prussia issued a warning declaration which the legislative assembly regarded as an unwarrantable and insolent interference with the domestic affairs of France. Consequently it compelled Louis to declare war upon Austria, Leopold having been succeeded at that moment by his son Francis II.

The troops were dispatched to the front—that is, the north-western or Austrian Netherlands frontier. Then Paris was seized with a panic in belief that the "aristocrats" were organizing a *coup de main* in conjunction with foreign invaders. The Jacobins captured the Commune; they made the royal family prisoners and, in the September Massacres, 1792, a large number of "suspects" were put to death in the prisons of Paris by the mob. Almost at the same moment news arrived that the advancing Prussians and Austrians had been driven over the frontier after their failure at Valmy.

At the end of the month the legislative assembly was dissolved, and its place was taken by a newly elected national convention. In the convention republicans were overwhelmingly dominant. It proceeded at once to proclaim the abolition of the monarchy and the establishment of the republic. Extraordinary success attended the troops in every theatre of the war now in progress, and the leaders who had taken the place of Mirabeau, in the words of Danton "flung down to the kings of Europe the head of a king as the gage of battle."

Louis was guillotined in January 1793, and the "Reign of Terror" began. Marie Antoinette followed her husband to the scaffold in October.

Up to the execution of Louis, Pitt had not been without some sympathy for what was believed in England to be a genuine if blundering attempt to copy British precedents; but revolutionary France now declared war on Britain, February 1, 1793; thenceforth Britain remained her most consistent enemy.

LESSON 15

The Rise of Napoleon

APART from the financial difficulties which beset the men of the French republican government after the declaration of war against Britain in 1793 it had also to deal with the problem of food supplies, for the coasts of all French territories were blockaded by the British navy. The communes of the larger towns introduced a rationing system with food cards; later the state requisitioned food and sold it cheaply.

The Revolution failed to establish democracy in France. From the rise of the Committee of Public Safety, 1793, already the government ceased to be democratic in form, and from the fall of Robespierre, 1794, it ceased to be democratic in substance. The France which emerged was a France in which the bourgeoisie was the predominant class. From the end of the Terror, which came with the execution of Robespierre, its leading spirit, on July 28, 1794, the tone of public life changed. The men of the Revolution—moderate Girondins, extremist Jacobins, the followers of Danton, of Robespierre, and of other apostles of violence—had wiped each other out. The subsequent consulate and the empire under Napoleon completed the destruction of democratic forces for a time, but restored order to the various departments of public life.

At the beginning of the war in 1793 the administration of the French armies was placed in the hands of Carnot, who devoted himself to the task with skill. The French Republic, which had taken over the government of an apparently bankrupt state, was able to defy the armies of all Europe and to defeat them repeatedly. Robespierre controlled the Committee of Public Safety, which sent out its agents empowered to act everywhere with arbitrary authority. Revolts in La Vendée and elsewhere were suppressed; Toulon, still royalist, was besieged; and suspects were slaughtered with a horrible ferocity. In Paris for several weeks the guillotine had an average of 50 victims a day, while supreme authority, amounting to a personal dictatorship, was exercised by Robespierre. He was carried to the pinnacle of power by his ruthless competence and the force of his fanaticism. Marat had proclaimed him "The Incorruptible." He became in effect the high priest of a religion of revolution.

Joséphine de BEAUHARNAIS (1763-1814), the handsome widow who married Napoleon Bonaparte in 1796. He divorced her in 1809.

Toulon was captured from its royalist defenders in December 1793, in spite of the British fleet, mainly by the skill of Napoleon Bonaparte (1769-1821), a young artillery officer whose military skill had already won golden opinions from Carnot—and who was French by the accident that Corsica, his birthplace, had been acquired by France from Genoa the year before he was born.

Meanwhile, Robespierre had struck down first one group of his colleagues, the Hébertists, whose extremism had gone beyond what he could endure, and then Danton, who had latterly been exerting his influence on the side of moderation. The Girondins, the party who might be called the literary republicans, had been "liquidated" long before. But the Terror had reached an intolerable height. A combination was suddenly formed against Robespierre, who, with his two colleagues, Saint-Just and Couthon, was in his turn struck down in July 1794.

The Directory

The government which replaced that of Robespierre produced a new constitution. A council of five, called the Directory, was to have the supreme administrative control, supported by two legislative assemblies. The plan was violently opposed in Paris; when the time arrived for the election of the assembly there was an insurrection in the capital. Barras, the head of the Five, and Carnot were produced for the emergency, and had chosen as their agent for crushing the insurrection the young artilleryman who had taken Toulon. Bonaparte's cannon cleared the streets and the Directory was established.

Bonaparte's marriage, early in 1796, with a fashionable widow, Joséphine de Beauharnais, strengthened his reactionary tendencies. He had exchanged Jacobinism for a cynical opportunism when in March of the same year he was ordered by the Directory to take command of the French armies in Italy.

Bonaparte in Italy

Of the circle of enemies who had not yet dropped off was the king of Sardinia, whose possessions of Savoy and Piedmont commanded the passage between France and northern Italy, which now, as always, was one of the battlefields with Austria. The object of Bonaparte's plan of campaign was to force Sardinia into neutrality, and to win the rest of north Italy from Austria. The campaign was conducted with an extraordinary brilliance and with a total disregard of the stereotyped rules of strategy.

By the swiftness of his movements Bonaparte, with smaller forces, was able to surprise the central Austrian army at Montenotte, and shatter it so that the second Austrian army had to fall back to the eastward. The king of Sardinia, forced to retire westwards, found himself isolated, and hastened to make peace. Bonaparte secured Milan by a brilliant victory at the bridge of Lodi. Naples, supposed to be in alliance with Austria, made its own peace instead of going to Austria's help. New Austrian armies advanced but Bonaparte shattered them at Arcola and Rivoli. In 1797, acting on his own responsibility, he advanced out of Italy, threatening Vienna, and forced upon Austria the treaty of Campo Formio

THE YOUNG BONAPARTE. Napoleon Bonaparte (1769-1821), a Corsican, joined the French army, and in 1796 was put in command of the forces in Italy.

which ceded to France the Austrian Netherlands and recognized her conquest of Lombardy. On the pretext that an unfriendly Venice was a danger, he had occupied the city, blotted out the Venetian Republic, 1797, and carried off the chief art treasures to grace the Louvre in Paris : the famous bronze horses he had removed from St. Mark's to be placed on a triumphal arch (they were returned in 1815). The British were now isolated ; but in February 1797 the fleet under Admiral Jervis had won a decisive victory at Cape St. Vincent over the Spaniards, who had allied themselves with the French. On October 11, six days before the treaty of Campo Formio, the British fleet under Admiral Duncan destroyed the Dutch fleet in the battle of Camperdown.

Battle of the Nile

Bonaparte, though not yet 30, had been made by his successes the most powerful man in France. Seeing no prospect of destroying the British navy he formed the design of seizing upon Egypt as a base for securing western Asia, and making that in its turn the base for striking at India on the one side and at Europe on the other. The Directory in Paris were well enough pleased to get their too-powerful general out of the way for a time. Bonaparte's armament set out from Toulon on May 19, 1798, evading the British Mediterranean fleet commanded by Nelson (1758–1805). Bonaparte's force reached Egypt. Nelson went in pursuit, and after searching the Levant coast, discovered it in the bay of Aboukir, where he won the overwhelming naval victory usually called the battle of the Nile, August 1, 1798. The French Mediterranean fleet had ceased to exist ; Bonaparte in Egypt was completely cut off and isolated from his real base in France. Hence, although he mastered Egypt itself, he failed in the attack launched therefrom upon Syria, for he could not advance without securing the port of Acre, and Acre proved impregnable.

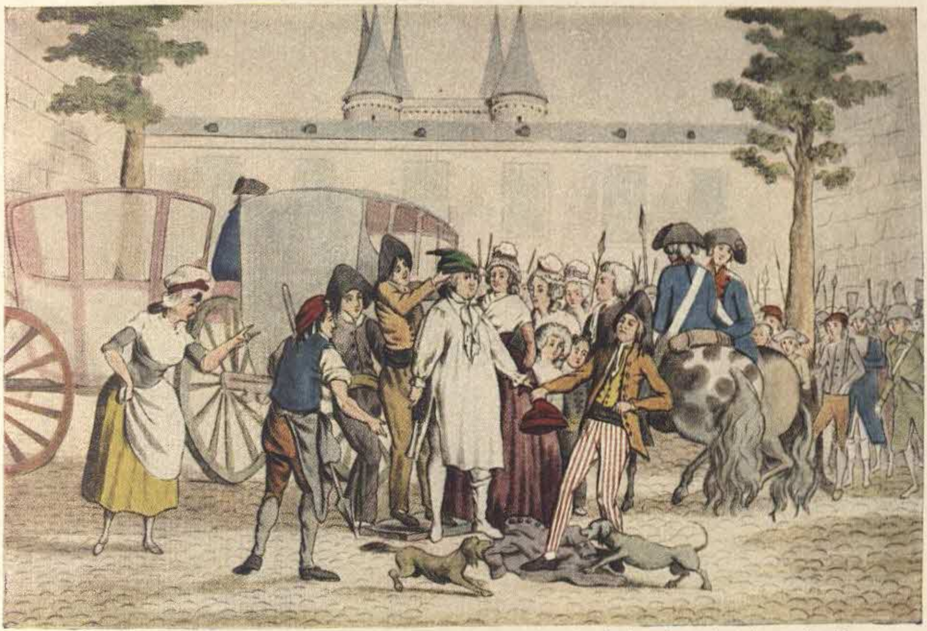
Russia, where the tsar Paul had succeeded Catherine, joined Great Britain, and Austria again declared war upon France. The Bourbon monarchy was restored at Naples, and the Russian general Suvarov was conducting a successful campaign in northern Italy when Bonaparte at last learnt what was going on in the west, events of which no news had reached him in Egypt. He decided that the moment had come when he must assert himself, and get the government of France into his own hands. Leaving his subordinate Kléber in charge of the army, he took boat with a few companions and hurried to Paris, where he was hailed as the conqueror of Egypt.

The First Consul

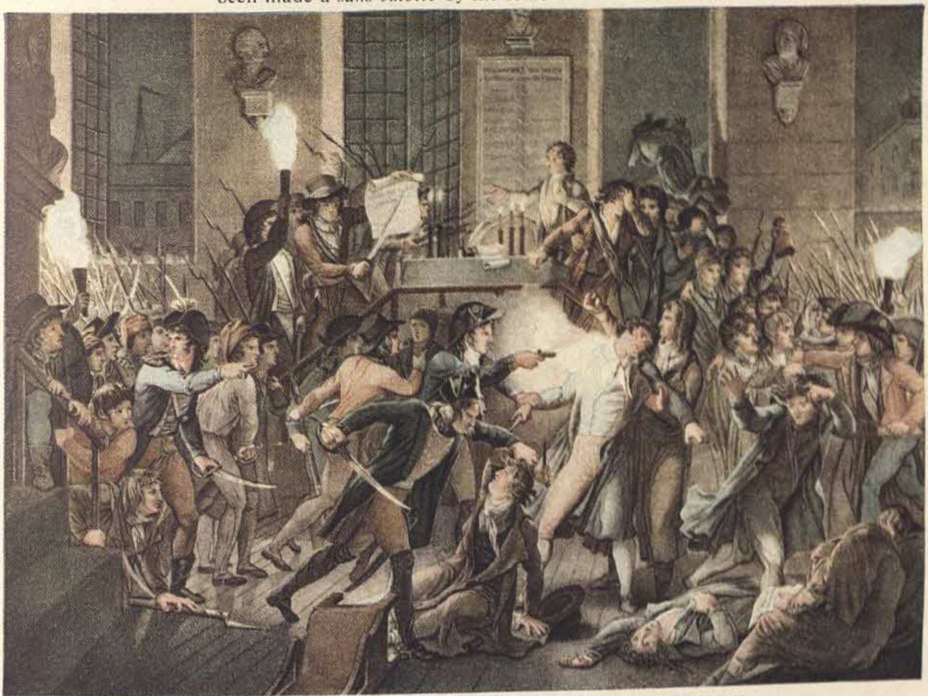
Bonaparte overthrew the corrupt and inefficient Directory with little difficulty, and with the active connivance of two of its members. The upper of the two legislative assemblies established under the Revolution immediately placed him in command of the armed forces. The lower, showing resistance to what its Jacobin members considered dictatorship, was cleared by Bonaparte's soldiers. The five directors were replaced by three consuls, of whom Bonaparte, First Consul, was alone appointed for a term of ten years. By the end of 1800 Bonaparte had assumed complete control. He was, indeed, welcomed by almost the whole of France, which was sick of anarchy and ready to accept any form of government that promised stability.

If he could have adopted a peaceful policy abroad, his success would almost certainly have been not only surprising but lasting. The tsar Paul had changed his attitude since he had discovered in the First Consul the incarnation not of revolutionary France but of absolutism. He was offended, not only with Austria but also with the British, because Great Britain, having captured Malta, did not hand it over to him, as had been intended when Russia was still a member of the coalition. He sought to revive a combination of the Baltic powers that had

BONAPARTE DISMISSES THE DIRECTORY. Knowing that the Directory (a committee of five appointed to govern in 1795) was unpopular, Bonaparte abolished it by the coup d'état of Brumaire in the year 8 of the Revolution (Nov. 9, 1799).



In this reproduction of a hand-coloured line engraving is depicted an imaginary incident during the drive of Louis XVI and his family from the hall of the Legislative Assembly to the Temple Prison on August 13, 1792. The king is being given a cap of liberty, and he has been made a *sans-culotte* by the removal of his breeches.



THE DOWNFALL OF LOUIS XVI AND ROBESPIERRE

On the night of the 9th of Thermidor (July 27, 1794) Robespierre was arrested in the Convention. In this picture a young gendarme called Méda is shown shooting at him; Robespierre's jaw was broken by the bullet. At the time it was widely believed that Robespierre had tried to commit suicide.

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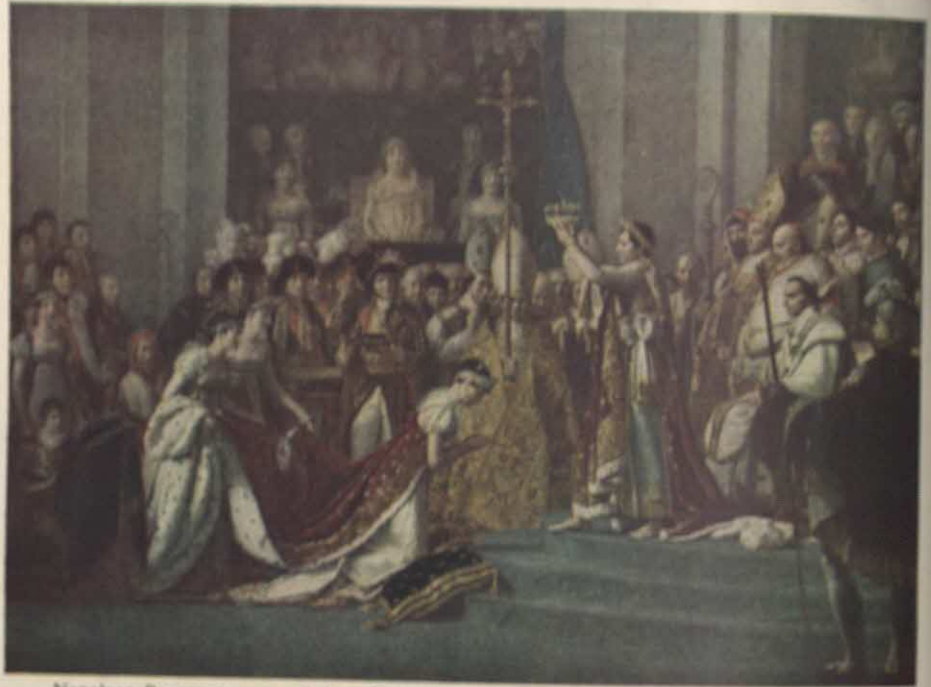
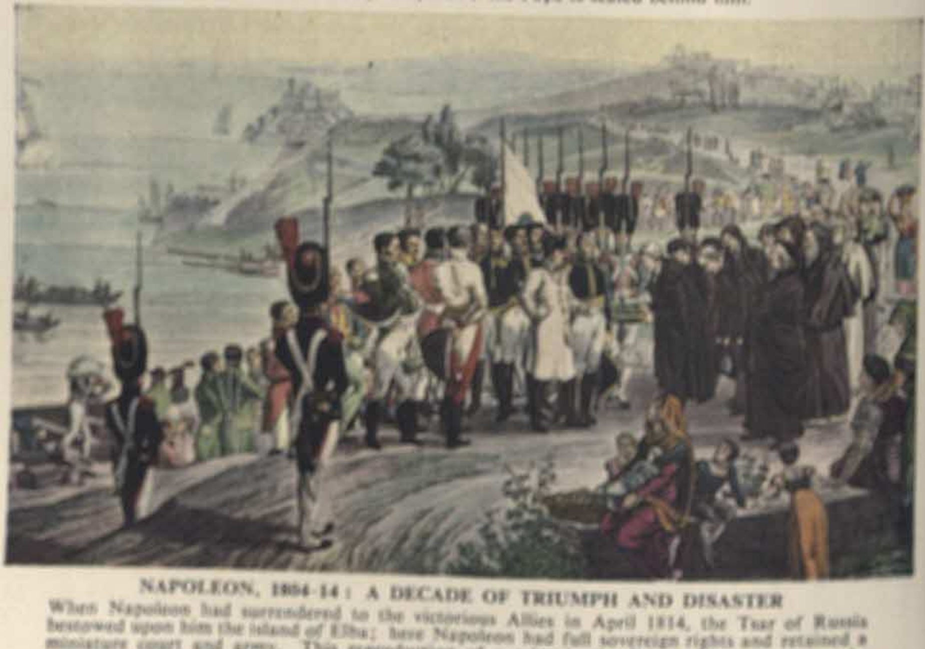


Napoleon Bonaparte crowned himself and his wife Emperor and Empress of the French in the cathedral of Notre Dame on December 2, 1804. The Pope, Pius VII, had journeyed to Paris to perform the ceremony, but before the high altar Napoleon put him aside. Here Napoleon is in the act of crowning Josephine ; the Pope is seated behind him.



NAPOLEON, 1804-14 : A DECADE OF TRIUMPH AND DISASTER

When Napoleon had surrendered to the victorious Allies in April 1814, the Tsar of Russia bestowed upon him the island of Elba; here Napoleon had full sovereign rights and retained a miniature court and army. This reproduction of a print in the British Museum shows the islanders welcoming their "emperor."

been formed in 1780 called the League of Armed Neutrality, which had been directed against the rights of search claimed by British ships, rights which were of the utmost value to a predominant naval power, but which were much resented by neutrals. It was clearly understood in England that the intention of the proposed new league was to place the fleets of Denmark, Sweden, and Russia at the disposal of France, and so to isolate Great Britain, for whom the sea was the only possible field of warfare.

A British fleet suddenly appeared before Copenhagen, with Nelson second in command. The Danes were required to hand over their fleet to the British for protection. They refused, but were promptly forced to submission by the battle of the Baltic or Copenhagen, 1801, won by Nelson who declined to see his senior officer's signal when ordered to cease firing. The Danish fleet was carried off; the assassination of the tsar a few days earlier had raised to the throne Alexander I (1777-1825) who was completely antagonistic to his father's ideas, and desired British friendship. At the same time a British expedition terminated the French occupation of Egypt and compelled the withdrawal of French troops. The war was brought to a conclusion by the peace of Amiens, March 1802.

LESSON 16

Napoleon: Legislator and Conqueror

The First Consul had, in effect, though not yet in name, transformed the republic into an absolute monarchy. The Revolution had produced a series of constitutions intended to establish democracy, but none had proved workable. The old aristocratic régime of privilege had, however, disappeared; and the people at large had been relieved from their real grievances. That accomplished, they cared little enough about actual participation in government. They were ready to acquiesce in the new despotism, and Bonaparte at once set about the internal reorganization of the country. In this task he had the immense advantage that he was without political prejudice and was prepared to draw on what was good in both the old and the new régimes.

DUC D'ENGHIEN (1772-1804). A noble of Bourbon blood, he was falsely accused of plotting against Napoleon and was shot.

With the help of Gaudin, a former official of the monarchy, he restored the national finances. He re-introduced the observance of Sunday, which had been abolished during Robespierre's ascendancy. He re-opened the churches, restored to their livings those clergy who promised not to oppose the constitution, and recognized the Pope as head of the Church. (But he did not restore to the Church its former possessions.) He proclaimed a general amnesty, and some 40,000 families returned from exile. He reorganized the educational system, holding that one of the chief aims of education was to produce subjects loyal to him and his successors. He created a new nobility, and established or re-established the council of state, the public accounts office, the courts of justice, the universities. He placed each department in charge of a prefect (an official whose position was very like that of the "intendants" of the old régime), and he placed sub-divisions of departments in the charge of sub-prefects.

Most important and far-reaching of his reforms was the codification of the law. Although it is still commonly called the "Code Napoléon," Napoleon Bonaparte's personal share in the drafting of the "code civil" was not great—he delegated that work to a commission of his appointment. But he continually insisted that the new code of law must not undo the work of the Revolution, and at the same time must be designed to maintain order in the country. The resulting code united all that was most suited to conditions in France at the beginning of the 19th century from the ancient Roman law, from traditional law, and from the laws of the Revolution.

So sound did both the forms of government and the legal code he established prove that, with modifications, they survived all the changes in government down to the occupation of France by the Germans in 1940. The Code Napoléon also had a profound influence outside France, for in the course of his conquests Napoleon introduced French law into the countries he overran; and as this was generally superior to the systems it displaced, the Code Napoléon remained to a large extent the basis of law in Scandinavia, Switzerland, the Low Countries, Italy, and several of the German states until the upheaval of European life and administration caused by the Nazi Revolution of 1933 and the subsequent war of 1939-45.

Bonaparte—or Napoleon as he began to call himself, after the manner of kings, while he was still First Consul—loved display, and his court became as splendid as the old courts of the Bourbons. Under his direction an admirable administration devoted itself to the production of magnificent public works. Emulating the ancient Romans, and, like them, with an eye to the rapid movement of troops, he constructed the splendid roads which form one of France's major means of communication. He transformed Paris from a medieval town to a modern city with wide streets and quays, fine bridges, and triumphal arches.

But Napoleon did more than engage himself upon domestic administration. During the short period of peace that followed the peace of Amiens he began re-organizing Germany in his own interests. Theoretically, Germany was re-organizing itself, a diet having been established to that end. But practically, it was controlled in the interests of France and Russia, and incidentally of Prussia, because the two great powers on the east and west intended Prussia to counter-balance Austria. In fact, the process meant the actual absorption by France or Prussia of German territories.

In spite of the peace of Amiens neither France nor Britain was in any haste to carry out the terms agreed upon. Each power suspected the other of intending to wait till its rival's evacuations were completed to declare its own purpose of not carrying out its own evacuations at all. The peace proved to be only a truce. As the months passed, relations became more and more strained, and in the summer of 1803 war was again declared.

Napoleon occupied Hanover and threatened invasion of England. He massed his troops at Boulogne, waited for an opportunity, and tried to create one. But while British fleets held the command of the Channel, a French army could not be ferried across and landed.

AFTER AUSTERLITZ. On December 2, 1805, Napoleon defeated the Russians and Austrians at Austerlitz. This picture, from a painting, shows the meeting of Napoleon and Francis of Austria after the battle.

The British, on the other side of the Channel, got together regiments of volunteers. Pitt's government and the naval authorities were perfectly confident that the opportunity would never come for an effective landing. All the fighting was in the nature of privateering raids upon commerce, because the French ports were watched, and no French squadron could put to sea without imminent risk of total destruction; and Britain had no army with which to attempt an invasion of French territory.

Napoleon as Emperor

It was now that Napoleon shocked Europe and terrorised the French royalists by kidnapping on German soil, and then shooting, the Duc d'Enghien, a member of the house of Condé and of Bourbon blood, falsely accusing him of participation in a royalist plot. This crime outraged the collective conscience of Europe and made an active enemy of the young tsar Alexander. In another sense it succeeded, for it placated the remnant of Jacobins, who now supported Napoleon's assumption of the imperial title. This he took, crowning himself emperor in Notre Dame on December 2, 1804. He hoped to gain European recognition and security against Bourbon conspiracies. But the tsar Alexander joined with Pitt in efforts to build up a new coalition against him. In the summer of 1805 the coalition was joined by Francis of Austria, though Prussia still held aloof. Russia and Austria now set about preparing their armies for a renewal of the war.

Plan to Invade England

Napoleon meant to strike his decisive blow at Britain before the general conflagration should break out. His plan was to divide the British fleet by enticing Nelson to the West Indies. Villeneuve, with the decoying fleet, was to evade his pursuer, return to Europe, release the fleet blockaded in Brest, crush the Channel fleet, and so clear the way for the army at Boulogne to be hurled upon the shores of Britain. As a matter of fact, the British fleet was quite prepared to give a satisfactory account of the French fleet even in the absence of Nelson and his squadron. Villeneuve did decoy Nelson away, and did return with Nelson in chase, but he did not relieve Brest. News had reached England and he found a squadron under Calder waiting for him off Cape Finisterre, saw that the plan was hopeless, and retreated to Cadiz. A few weeks later Nelson had rejoined the Mediterranean squadron; the combined French and Spanish fleets put to sea, and were caught and annihilated by Nelson at the decisive battle of Trafalgar,

NAPOLEON AT TILSIT. After his defeat at Friedland, Alexander I abandoned his Prussian ally and made terms with Napoleon. The two met on a raft on the Niemen at Tilsit. This picture, from Serangeli's painting, shows Napoleon taking leave of Alexander.

October 21, 1805. Trafalgar set the seal on British naval supremacy, but Nelson died in the battle. (*See also* the Course : BRITISH HISTORY.)

Villeneuve's retreat to Cadiz had been enough to prove to Napoleon the futility of his scheme of invasion. Without hesitation he resolved to strike at once against the coalition on the Continent. The army of invasion was hurled across Europe, and swooped down on the main Austrian army, which was gathering at Ulm. The day before Trafalgar was fought, the Austrians were forced to capitulate. In three weeks the French were in Vienna. The Russians were coming up, and a second Austrian force was moving to join them. On December 2, at Austerlitz, Napoleon fell upon the combined force, and won a complete and decisive victory. The king of Prussia, who had been thinking of joining the coalition, changed his mind. The Russians retired in disgust, and Napoleon dictated his terms to Austria in the treaty of Pressburg (Bratislava).

Napoleon at his Zenith

Before his victory at Austerlitz, Napoleon, with an unfriendly Prussia on his flank, was in a somewhat difficult situation ; after it he gave the law to the Continent. Previously the north Italian republics had invited him to accept the crown of the kingdom of Italy ; the remaining Austrian provinces in Italy were now annexed to that kingdom. Outlying Austrian provinces in Germany were transferred to German princes who had supported Napoleon. Prussia was momentarily placated with the promise of Hanover. Some dozen German principalities were combined in the Confederation of the Rhine, and thus prepared for the formation of a large Napoleonic-German union. The emperor presented three of his brothers with kingdoms. That of Westphalia, composed of some German principalities, was bestowed upon Jerome in 1807. Louis was, during the years 1806–10, made king of Holland ; and Joseph was given Naples, whence the ejected Bourbon monarch betook himself to the island of Sicily, at that time virtually under British control.

Frederick William III of Prussia had pursued a wavering policy, unwilling to take either side ; but in 1806 Napoleon pressed the Prussians too hard, and war ensued, only to result in disastrous defeats at Jena and Auerstädt on the same day, October 14, 1806. Napoleon occupied Berlin, and the Prussian king fled to Memel, on the Niemen. Tsar Alexander came to his aid ; the joint Russian and German forces advanced, but were defeated at Friedland in June 1807. The tsar then deserted Prussia, met Napoleon at a secret conference, and the two potentates arranged the terms of the treaty of Tilsit by which they agreed to make common cause against any power which did not accept the mediation of one of them. Prussia was penalised by the loss of Polish territories, which, in the form of the grand duchy of Warsaw, were handed over to Saxony, Napoleon's constant ally.

To England it mattered little that the Austrians and Prussians were crushed by the French. They knew that after Trafalgar there was no fear of a French invasion.

The Continental System

To the peoples of Europe, however, Trafalgar seemed a very small thing in comparison with Austerlitz or Jena. Napoleon was probably the one man on the Continent who, without in the least undervaluing his own victories, could understand that the battle of Trafalgar destroyed, for the time at least, any possibility of an invasion of England. He saw that other means must be found for breaking her power. He therefore framed a design for ruining British commerce, the source of wealth and therefore of power. This scheme, called the Continental System, he formulated in decrees issued from Berlin and Milan in 1806 and 1807. No British goods or goods borne in British ships were to be admitted to any port under French control or in the hands of any government in dependence upon the French empire. He backed up these decrees by encouraging the use of substitutes, in the hope of making the Continent of Europe permanently independent of products brought from the British colonies and by

British ships. He advocated the use of chicory instead of coffee, and stimulated both the cultivation of the sugar beet (to replace the cane sugar of the West Indies) and the discovery of new dyes to replace those coming from the tropics.

Great Britain replied by orders in council which declared that all ports closed to British goods were in a state of blockade, and were consequently not open to any neutral commerce whatever. A very lucrative, if dangerous, business was developed for the smuggling of British goods into the Continent, and the French government itself was obliged to grant licences enabling the holders to import absolutely necessary goods. On the other hand, the Continental System was a blunder—the fundamental cause of Napoleon's ruin. The pressure it imposed on Europe was the most potent cause of the revolt against the Napoleonic domination. British commerce was checked, but Continental commerce was on the way to being throttled.

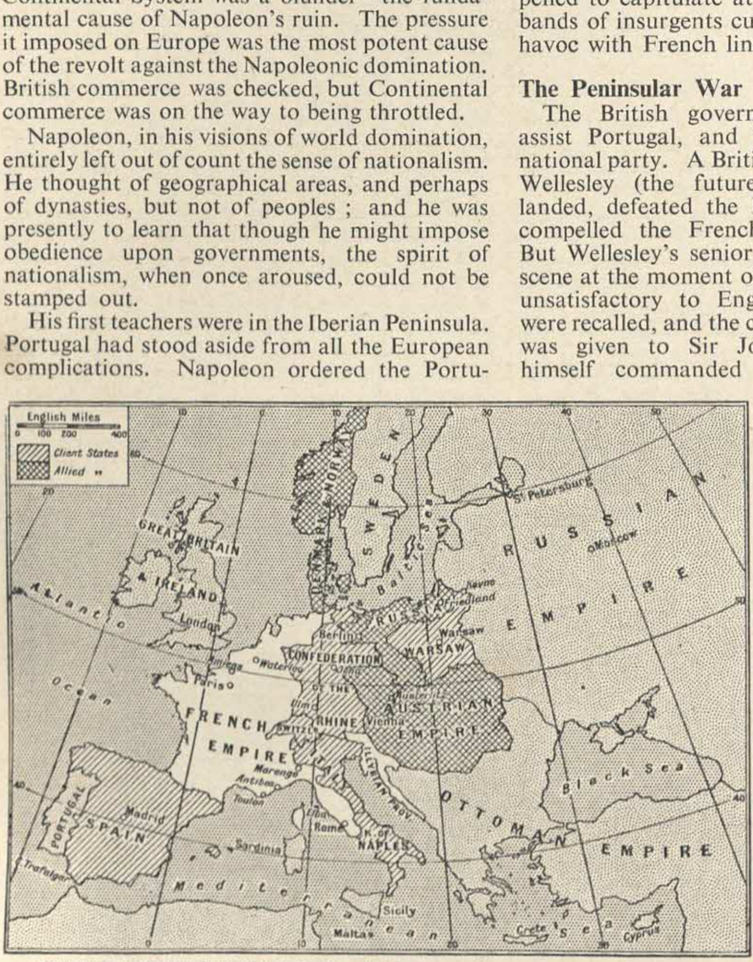
Napoleon, in his visions of world domination, entirely left out of count the sense of nationalism. He thought of geographical areas, and perhaps of dynasties, but not of peoples ; and he was presently to learn that though he might impose obedience upon governments, the spirit of nationalism, when once aroused, could not be stamped out.

His first teachers were in the Iberian Peninsula. Portugal had stood aside from all the European complications. Napoleon ordered the Portuguese government to join the Continental System ; it refused. French troops entered Portugal, which appealed to Britain. At the same time Napoleon forced the abdication of the Spanish king and his son, both of whom were incompetent, and brought his own brother Joseph to occupy the throne of Spain, transferring Joseph's Neapolitan kingdom to their brother-in-law Marshal Murat.

The Spanish people, however, refused to accept a king at Napoleon's dictation and broke out into a fury of insurrection. French troops swept over Spain and, as a matter of course, were too strong in the open field for such Spanish armies as could be raised. Nevertheless, a French force was trapped and compelled to capitulate at Baylen, and everywhere bands of insurgents cut off supplies and played havoc with French lines of communication.

The Peninsular War

The British government resolved now to assist Portugal, and to support the Spanish national party. A British force under Sir Arthur Wellesley (the future Duke of Wellington) landed, defeated the French commander, and compelled the French to evacuate Portugal. But Wellesley's senior officers, arriving on the scene at the moment of victory, conceded terms unsatisfactory to England. All the generals were recalled, and the command in the Peninsula was given to Sir John Moore. Napoleon himself commanded the forces engaged in crushing Spanish resistance in the south, when Moore marched upon his lines of communication. The emperor, having other objects in mind besides the quelling of the Spaniards, left Marshal Soult in command. Napoleon never returned to the Peninsula. Moore, compelled to retreat to Corunna, 1809, repulsed Soult's attack there ; but he was killed in the engagement.



EUROPE UNDER NAPOLEON. This shows Europe in about 1810, when Napoleon was at the height of his power, and the only countries outside his influence were Gt. Britain, Portugal, Sweden, Russia, Turkey, Sardinia, and Sicily. The French empire included the Netherlands, Oldenburg, Hamburg, Lübeck, the kingdom of Rome, Illyria, Piedmont ; the remaining states were allies of France.

With the return of Wellesley in the spring, the Peninsular War really began, and Britain took the rôle of a military as well as a naval power for the first time since the days of Marlborough. For four years a quarter of a million of French troops were locked up in the Peninsula, vainly endeavouring to suppress the Spanish guerrillas and their British ally.

In 1809 Wellesley won the victory of Talavera and the title of Viscount Wellington (he was not made Duke of Wellington until 1814). He was obliged, however, owing to the insufficiency of his forces, to fall back into Portugal, where he organized an impregnable position covering Lisbon behind the lines of Torres Vedras. In 1810 Napoleon dispatched Masséna against him. Wellington checked him at Busaco, but was forced to retreat to Torres Vedras. In the spring of 1811 he advanced against Masséna again, and beat him at Fuentes d'Oñoro. At the beginning of 1812 Wellington captured the frontier fortresses of Ciudad Rodrigo and Badajoz, and in July completely routed the French at Salamanca ; but even then, though Wellington occupied Madrid, he had to fall back once more into Portugal.

LESSON 17

Napoleon's Decline

NAPOLEON wanted an heir to the vast domain he was creating, but his wife Josephine had borne him no children. In 1810 he therefore divorced her ; and shortly afterwards, in the same year, married Marie Louise, daughter of Francis, first emperor of Austria. (Francis, who had been elected Holy Roman Emperor in 1792, in 1804 assumed the style Emperor of Austria, and after 1806 never used his former hollow title.) This brilliant marriage seemed to consolidate his position, especially as the following year Marie Louise bore a son, who was proclaimed king of Rome ; but the ceremony of proclamation fixed for 1812 did not take place. Napoleon was then entering upon the fatal adventure in Russia which indirectly led also to the expulsion of the French forces from the Peninsula in 1813.

Victory of Wagram

When Napoleon had left his marshals to complete the subjugation of Spain and Portugal and drive out the intruding English, the war in the Peninsula had seemed to him a side issue, and of its conclusion he entertained no doubt. In 1809 he had taken Tirol from Austria and presented it to his ally Bavaria ; both Austrians and Tirolese had resisted this disposal, at first with some success, only to be defeated at Wagram, July 6, 1809. Thereafter Austria had made peace, ceding at the treaty of Vienna portions of the empire.

Napoleon's Home Policy

The years of Napoleon's supremacy (1809–12) were marked by great public works, which brought new life not only into France but into central Europe. The Code Napoléon had beneficent results in Italy, Switzerland, the Confederation of the Rhine, and the Grand Duchy of Warsaw. Education was improved and religious toleration extended. In Italy, as in Germany, he struck at the abuses of the old régime, sweeping away petty states and unifying the people in larger territories, within which were free trade, equality of law, education, and the semblance of a popular government.

His experiment of a " United States of Europe " required, however, years of peace for its materialisation, and peace was still far from Napoleon's plans—far also from the minds of the king and tsar he had humiliated. Prussia, though he did not know it, was being secretly re-organized, and the Prussian minister Stein, who had begun the re-organization, was in the tsar's service. At the end of 1811 the tsar broke away from the Continental System, making it clear that Russia, dependent as she was on imported goods, could no longer endure this harsh fiscal policy.

MARIE LOUISE (1791–1841), daughter of Francis of Austria, and second wife of Napoleon.

Napoleon in Russia

Russia's defection meant wreck to the whole scheme ; hence in 1812 Napoleon resolved to compel submission. He collected the " Grand Army "—half a million men—and in June crossed the Niemen.

But the Russian armies declined battle. They retreated continually, fighting only rear-guard actions and stripping the country of supplies, till they turned at bay at Borodino, where Napoleon gained a victory at enormous cost. Again the Russians retired ; a week later he was in Moscow. But Moscow was in flames : the Russians—whether by accident or design is not known—had fired the city and made no attempt to hold it. For a month the depleted Grand Army abode in the gutted town, with no supplies. Then, on October 18, it set out on the return march across country already laid bare, with the Russians hovering on its flank cutting off supplies and stragglers. The cruel Russian winter descended on the starving and exhausted troops. In December

RETREAT FROM MOSCOW. Realizing that he could not winter in Moscow, Napoleon began the fatal retreat of 1812. Soon the winter set in, and only a fragment of the Grand Army managed to re-cross the Russian frontier. This picture, after Atkinson, conveys an idea of the misery of the retreat.

a mere remnant of Napoleon's mighty army struggled back over the Niemen into Prussia. Ney commanded the rearguard. Napoleon had hastened ahead to try to save the situation in the west. But from this immense disaster his fortunes never recovered.

Prussia and Austria were both Napoleon's allies, but neither was disposed to aid him. Prussia was an ally only because since Jena and Tilsit she had had no choice. In February 1813 she became Russia's declared ally. Metternich, the astute statesman who now led Austria, held aloof, waiting to snatch Austria's advantage as the new situation revealed itself. In Paris, Napoleon was organizing new armies, calling in troops from Spain, cowing the west Germans. In May and June he was able to defeat the Prussians heavily at Lützen. But he obtained no help from Austria ; Metternich, hearing of Wellington's victory at the decisive battle of Vittoria, and that the depleted French armies were in full retreat from the Peninsula, saw that Napoleon's position was really critical and that his demands were extreme and impracticable. In stormy interviews the statesman and the emperor failed to come to any agreement, and Metternich at length decided to join the Allies.

Battle of the Nations

Napoleon won his last victory at Dresden (August 26–27, 1813) ; elsewhere things went badly for him, his lieutenants suffering serious reverses at the hands of the Allies. Then at Leipzig, October 16–19, was fought the " Battle of the Nations," which ended in Napoleon's defeat and retreat over the Rhine. He still refused the offered terms, which would have left the Rhine, the Pyrenees, and the Alps as the boundaries of France. Through the first three months of 1814 he continued to fight on French soil, defeating the armies of the Allies in detail (while Soult and Wellington were fighting in the south), but unable to stay the advancing tide. On March 29 the Allies entered Paris; the last point, Montmartre, capitulated on the 31st. Under pressure from his marshals, Napoleon signed a deed of abdication on April 11, 1814.

The Allies bestowed on him the principality of Elba (a small island between Corsica and the Italian coast), made a preliminary settlement of European boundaries, restored the exiled Louis XVIII to the throne of France, and arranged for a great congress to be held at Vienna in the autumn to make a permanent settlement. The four great powers, Austria, Russia, Prussia, Great Britain, with monarchical France, were to act together for the restoration of universal peace. But when they met at Vienna the points of disagreement seemed likely to set them quarrelling instead, till the startling news arrived that the exile had slipped back from Elba, that he had landed in France on March 1, 1815, that he was on his way to Paris, and that many veterans of his campaigns were flocking to his standard. King Louis took hasty flight from his capital, and Napoleon was proclaimed emperor once again.

The discords of the powers were hushed. Napoleon might make the most pacific declarations, but no power in Europe dared to trust him. Napoleon's affairs were under the direction of a single brain and a single will—his own—whereas those of the Allies were controlled by half a dozen different brains and wills. He resolved to strike at once, and destroy his enemies separately before they had time to act together.

Napoleon's Defeat at Waterloo

The armies of Austria and Russia were far away. In the former Austrian Netherlands (which had been incorporated in France in 1797) there was a heterogeneous collection of regiments, British, Germans, and Dutch, with the duke of Wellington in command ; near at hand the Prussian forces were assembled under Blücher, when, some three months after his first reappearance in Paris, Napoleon advanced northwards. His object was to strike between Blücher and Wellington before they could effect a junction, and to shatter first one and then the other. He almost succeeded. At Ligny he defeated Blücher and drove him to retreat. Then he turned upon Wellington, who took up his station at Waterloo, covering

Brussels. Blücher, however, aware of the vital importance of effecting his junction with Wellington, had not fallen back to his own base at Namur, as Napoleon supposed, but had wheeled northwards upon Wavre, thereby eluding the force which had been detached to hold him in check while Wellington was being annihilated.

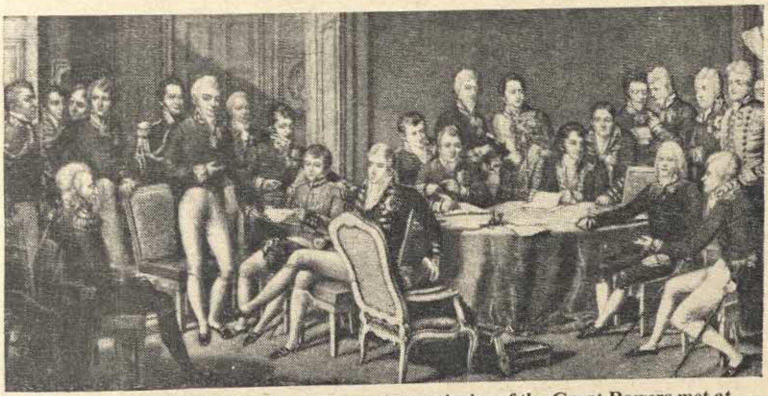
On June 18, 1815, Napoleon and Wellington were facing one another. From a little before midday till late in the afternoon a stubborn battle raged, Wellington obstinately holding the slopes against the furious attacks of the French. But as the afternoon advanced, Blücher's troops were coming up from Wavre. Their arrival on the scene of conflict was decisive. As they crashed in upon the French right, the thin red lines of the British hurled back the desperate last onslaught of Napoleon's Old Guard and swept forward. The French broke, the defeat became a rout, with the Prussians in pursuit. Napoleon's cause was hopelessly lost. A few days later he surrendered himself to the commander of a British warship. By the agreement of the powers he was sent to spend the remainder of his days on the lonely rock of St. Helena, far away in the South Atlantic. He died there on May 5, 1821.

LESSON 18

The Congress of Vienna and After

After the four great powers—Great Britain, Austria, Russia, and Prussia—had disposed of the "disturber of European peace," the Vienna Congress returned to its task of restoring Continental equilibrium. The basic principle adopted was the replacement, with undiminished realms, of the legitimate dynasties of the pre-war days, wherever they had been dispossessed by revolutionary and imperial France. Between them the four great powers reconstructed the map of Europe to their own advantage. In restoring the Bourbon monarchy to France they insisted upon the provision of a constitution, a course to which Louis XVIII agreed without demur. The other Bourbon kings, Ferdinand of the Two Sicilies and Ferdinand of Spain, were respectively restored to Naples and Madrid. France retained her pre-war boundaries, as laid down in the peace of Paris, 1814, but was not admitted to the status of the four great powers; she remained under military supervision, and a war indemnity was levied on her as a defeated country. Otherwise all the princes of Europe were restored to autocracy. It occurred to no one to consider any but dynastic interests; populations were transferred without consulting them.

The king of Sardinia recovered Piedmont; William of Orange became king of the Netherlands (including the former Austrian Netherlands); Austria received compensation elsewhere. German princes who had thrown in their lot with Napoleon were penalised for the benefit of Prussia; a kingdom of Poland, under the tsar's sovereignty, was re-created out of the grand duchy of Warsaw, which Napoleon had presented to Saxony. Norway, which had been attached to Denmark, was transferred (as a separate kingdom) to Sweden, which surrendered Finland to the tsar. The Austrian empire recovered the north Italian duchies, with Venetia; but the old Holy Roman Empire was not revived. Instead, the German states were formed into a German Confederation with the Austrian emperor as president, but without including the non-German divisions of the Austrian empire. Metternich was the guiding spirit in both the German and Austrian governments for another generation. Britain retained Malta and Gibraltar, returned Minorca to Spain, but kept Ceylon and Cape Colony by agreement with the king of the Netherlands;



CONGRESS OF VIENNA. The plenipotentiaries of the Great Powers met at Vienna in 1814 to reorganize the political system after the upheaval of the revolutionary and Napoleonic wars. In the midst of their deliberations came news of Napoleon's return from Elba, so that final settlement was not reached until June 9, 1815. This picture is from a painting by Jean Baptiste Isabey.

the king of England was reinstated in Hanover, as king, not as elector.

The four powers, as responsible for the peace of Europe, agreed to hold periodical congresses in order that all action might be co-operative. Tsar Alexander was a visionary who at the moment believed in granting his subjects liberties so long as they used those liberties in exact accordance with his own wishes. He set the other despots the example by granting a constitution to his new kingdom of Poland. Several of the minor despots followed his lead, but, as the constitutions did not convey any effective power, the despots continued to act as despotically as before.

ALEXANDER I of Russia (1777–1825) was the founder of the Holy Alliance between Russia, Austria, and Prussia.

The Holy Alliance

Almost all of them accepted the tsar's invitation to join a (personal) Holy Alliance of Christian princes pledging themselves to pursue Christian ideals in the government of their dominions, a pledge which as a matter of course they unanimously ignored ; so that, in practical effect, the Holy Alliance became a league of despots zealous to help each other in suppressing all movements towards such popular liberties as were in fact established in France and England, or that spirit of nationalism which resents subjection to an alien domination—a spirit which was active in Italy and among the Christian populations of the Turkish empire.

FERDINAND VII of Spain (1784–1833) was a bigoted despot, kept on his throne only by French bayonets.

In every country which had been under the domination of the French republic, the practice of France had implanted the conception of civic liberty. Spain, which had suffered most from the war—bridges broken, roads and villages ruined—was now ruled by a bigoted despot who had even succeeded in getting the Inquisition re-established. The Spanish liberal patriots knew that it was possible for an administration which was not priest-ridden to be efficient. They had also learnt from their English allies the value of parliamentary institutions. In central Europe, Metternich, though he felt fairly safe about Austria and the kingdom of Hungary, was more concerned about Germany and the large portion of Italy which had been restored to Austria in 1815. Germany was not the same country as it had been before the French Revolution. Under the Napoleonic scheme many small principalities had been absorbed into larger ones ; the left bank of the Rhine had been freed from feudalism and brought under the French civil code, which guaranteed equal liberty to all men irrespective of birth. The southern states had followed suit. Now, with the reaction, the princes had again cut up Germany.

The Italian situation had its own difficulties, partly owing to the civilization of the north of Italy and the backwardness of the south. Here again the allies cut to pieces the larger units formed under Napoleon's domination, distributing them under princes who were in some instances foreigners. Freemasons and Carbonari fraternised on both sides of the Alps ; Napoleon became almost a hero to many of the younger men, who formulated the political ideal of a secularised and unified Italy. On the Continent the aftermath of the French Revolution was not industrial troubles, as in England, but political and religious quarrels ; autocrats and the Church became close allies against the rising tide of liberalism.

FERDINAND II of the Two Sicilies (1810–59), whose cruel rule Gladstone called simply a " negation of God."

The dynasts had in their own hands the machinery for enforcing mastery. Nationalism, in the alternative and quite distinct sense of passionate desire for unification among peoples of one stock—German, Italian, or Slav—was a dream rather than an immediate political motive. The German Confederation and its diet were not more than a league and its council of states under Austria's hegemony, and neither the German princes nor Metternich wished them to be more, since nearly all were willing to follow Metternich's lead. In Italy a large area of which formed part of the Austrian dominion, the kings of Sardinia and Naples looked to Austrian support in the suppression of liberal movements.

Throughout Germany, then, the constitutional movement known to its supporters as liberalism was silenced. Ferdinand of Naples (the "Two Sicilies") was forced to accept a constitution which he repudiated as soon as he was assured of Austrian support. Ferdinand of Spain followed a similar course. Piedmont extorted a constitution from Victor Emmanuel of Sardinia, but his successor, Charles Felix, was enabled to cancel it by the aid of Austrian bayonets. Louis XVIII succeeded for a time in carrying on a government of moderates, so that in 1819 France was released from the fetters imposed on her at Vienna ; but from that time the ascendancy in the government passed to the king's brother and heir, Charles.

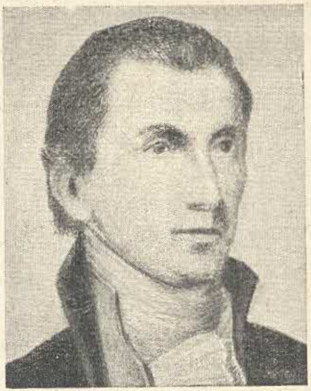
Monroe Doctrine

Meanwhile all the Spanish colonies in America were in revolt. European intervention in favour of Ferdinand of Spain was prevented by Castlereagh's successor, Canning, who on behalf of Great Britain recognized the insurgents as belligerents. As the people of one after another of Spain's colonies in South America asserted by force their right to independence, the United States recognized them ; and in 1823 Canning suggested the issue of a joint declaration by Great Britain and the U.S.A. But Great Britain had not then recognized the independence of the new states. John Quincy Adams, U.S. secretary of state, was against such joint declaration, and the president, Monroe, issued a message warning Europe off from interference in the affairs of the American continents. It embodies what came to be known as the Monroe Doctrine, and has ever since played an important part in the foreign policy of the U.S.A. The following quotations give the chief points of the Monroe Doctrine :

> (i) the American continents, by the free and independent condition which they have assumed and maintained, are henceforth not to be considered as subjects for future colonisation by any European powers ;
>
> (ii) the political system of the allied powers is essentially different from that of America . . . We owe it, therefore, to candour and to the amicable relations existing between the United States and those powers to declare that we should consider any attempt on their part to extend their system to any portion of this hemisphere as dangerous to our peace and safety . . . With the governments who have declared their independence and maintained it . . . we could not view any interposition for the purpose of oppressing or controlling their destiny, by any European power, in any other light than as the manifestation of an unfriendly disposition towards the United States.

In South America a number of independent but very unstable republics, generally under military dictatorships, were set up ; while Brazil declared itself an independent empire under the Portuguese crown prince Pedro, who on the death of his father, John VI, in 1826, chose to retain Brazil and transfer the Portuguese throne to his daughter, Maria, with her uncle Miguel as regent.

In the 14 years following the Congress of Vienna the old order held its own all over western Europe. Even the tsar soon abandoned his brief faith in the development of liberal principles. He was succeeded in 1825 by his brother Nicholas I, a conscientious believer in the most rigid autocracy, in whose eyes disobedience to the divine authority of the autocrat was the unpardonable sin, though the autocracy of the Turk was another matter. It was this distinction in the mind of Nicholas that helped the nationalist movement in Greece to fruition.



JAMES MONROE, president of the U.S.A. 1817–25, who promulgated the "Monroe Doctrine."

The Greek revolt against Turkey began in 1821. But the expected support from Russia was not forthcoming ; Metternich persuaded Alexander that to give it would encourage revolutionaries. The European Congress then sitting at Verona banned intervention. In Britain and France there was lively sympathy for the Greeks, but both were committed to the doctrine of non-intervention.

Greeks Achieve Independence

The balance of success was with the Greeks, owing to their greater skill at sea, till Sultan Mahmud called Mehemet Ali, pasha of Egypt, to his aid at the moment when Nicholas succeeded Alexander as tsar. It was obvious that Nicholas, intent on Russian interests, meant to intervene. But it was against British policy that Russia should dominate Constantinople, and Britain and France therefore persuaded him to an agreement for the three powers to force the belligerents to stop fighting. The attempt resulted in a battle at Navarino, Oct. 20, 1827, between the British and Turkish fleets, in which the Turkish fleet was sunk. Britain, under a new government, refused to be embroiled further. The tsar invaded Turkey and forced on the sultan the treaty of Adrianople, 1829, which established an autonomous Greek

FIRST KING OF MODERN GREECE. In 1832 the Convention of London declared Greece to be an independent kingdom under the protection of Britain, France, and Russia, and prince Otto, son of Louis I of Bavaria, became its king. In this way ended the Turkish domination, which had lasted nearly 400 years. This picture, after a painting by Peter Hess, gives an impressive idea of Otto's entry in 1833 into Nauplia, then the seat of the administration. Athens became the capital of Greece in 1834.

republic, and gave autonomy under Russian protection to Wallachia and Moldavia, Turkey's former trans-Danube provinces. Three years later, when Nicholas was much preoccupied with Poland, the powers combined to convert the autonomous republic into an independent constitutional monarchy under Otto of Bavaria, who in 1833 entered Nauplia.

The July Revolution

In France, Charles X, who had succeeded his brother Louis XVIII in 1824, and the monarchists were aiming at the restoration of absolutism. The Assembly and the city of Paris were restive ; but the country as a whole was clearly pleased at re-established material prosperity, while patriotism was gratified at the assertion of France's position as a European power over the Greek question, and at the success of a campaign in Algiers, 1830, which laid the foundation of France's North African empire. In 1830, therefore, Charles felt strong enough to defy the opposition of the bourgeois constitutionalists.

He had already gagged the press by dint of royal ordinance, and in July he promulgated an electoral law which would have shorn the Senate and the Chamber of Deputies of effectual parliamentary rights. So confident were Charles and his reactionary minister Polignac of success that they made no preparations for a counter-revolution. Paris, however, responded by setting up a provisional government which elected the king's cousin, Louis Philippe of Orleans, lieutenant-general of the realm. Charles abdicated and fled to England. Louis Philippe, the "citizen king," was without bloodshed raised to the throne as a constitutional monarch. The July Revolution of 1830 was a bourgeois revolution in which only for a moment Jacobinism had threatened to gain the upper hand.

LOUIS PHILIPPE (1773–1850). Head of the Orleans branch of the Bourbons, he was king of France 1830–48.

Creation of Belgium

The Congress of Vienna had brought together once more the whole of the Netherlands (divided by the treaty of Westphalia, 1648) to form the Kingdom of the Netherlands with William of Orange-Nassau, the last stadtholder, as king. The amalgamation was not harmonious : the two communities were too much separated by differences due to their different history. Moreover although the larger part of the people in the south spoke Flemish (which written is the same language as Dutch), the wealthier and more influential elements were, and still are, French-speaking. During the 15 years the union lasted the French-speaking Walloons chafed under the rule of William I. Their chief grievances related to taxes and language : they accused the king of trying to stamp out the French language.

When, in July 1830, the second revolution broke out in France, an immense agitation started in the southern Netherlands, culminating in a rising in Brussels on August 26. There were sympathetic movements at Liége, Namur, Tournai, and Mons, and everywhere outside Antwerp Dutch authority crumbled. William sent an army which entered Brussels, but after four days of fighting had to escape secretly in the night. Antwerp, except for the citadel, which held out another two years, passed to the insurgents.

Britain, France, Austria, Russia, and Prussia imposed a cessation of hostilities, and drew up articles eventually incorporated in a treaty of April 19, 1839, which established peace between north and south Netherlands, and recognized the independent and permanently neutral kingdom of Belgium, her neutrality being guaranteed by all the powers. Leopold of Saxe-Coburg, widower of Charlotte, only legitimate child of George IV, had been chosen king of the Belgians in 1831.

LEOPOLD I (1790–1865), an uncle of Queen Victoria, was chosen first king of the Belgians in 1831.

Reaction in Europe

In 1830 the people of Poland rebelled against the tsar Nicholas. The revolt was crushed, and the Poles lost such semblance of liberty as had survived the death of Alexander. In the same year Ferdinand II, later nicknamed " Bomba " from the savagery of his methods, succeeded to the throne of the Sicilies ; and in 1831 Charles Albert, a prince with nationalist and constitutional leanings, followed Charles Felix in Sardinia and Piedmont. Hanover's connexion with England was severed by the death of William IV in 1837. In the U.K. he was succeeded by his niece Victoria ; but the Hanoverian succession went to his brother Ernest Augustus, Duke of Cumberland—a bitter and stupid reactionary—for the Salic law of Hanover denied the right of a woman to the throne.

Both Spain and Portugal were torn by civil war. In Portugal, Miguel, regent for his niece, the child queen Maria da Gloria, attempted to seize the crown for himself ; a prolonged contest ensued, the constitutionalists supporting the child and expelling Miguel in 1834. In Spain Ferdinand died in 1833, leaving the crown by his own decree—in spite of the recently adopted Salic law—to his infant daughter Isabella, with the queen-mother Christina, his fourth wife, as regent. His brother Carlos claimed the crown. The constitutionalists supported the child, her mother accepting the " Constitution of 1812," which they had endeavoured to force on Ferdinand ; but Carlos was not finally ejected until 1839.

The Near East

Meanwhile affairs in the Near East had entered another phase. The treaty of Adrianople made Russian influence predominant in Constantinople, but Turkey was subjected to a new danger. The sultan Mahmud, who had been forced to cede Greek independence, was not popular with his Mahomedan subjects—he had surrendered to the infidel and he was a reformer. Moreover, he had irritated the strongest of his viceroys, Mehemet Ali, pasha of Egypt, by refusing to convey Syria to him—the reward he was to have received for quelling the rebellious Greeks, which he had failed to do.

Mehemet Ali

Mehemet invaded Syria. Britain and France offered Sultan Mahmud advice ; the tsar offered him troops. Mehemet compromised, while Mahmud by the treaty of Unkiar Skelessi virtually placed himself under Russia's protection, 1833. Five years later Mehemet renewed the challenge to his suzerain by withholding the Egyptian tribute. Mahmud dispatched an army against his recalcitrant vassal. Mehemet sent his son Ibrahim, an able soldier, to meet it. Mahmud died, leaving a young son, Abdul Mejid, as sultan. Ibrahim routed the Turks and threatened to march on Constantinople, while the Turkish admiral handed over his fleet to Mehemet.

The four leading European powers were particularly interested. To Austria, Russian domination of the Turkish empire was a menace. Russia had, since the days of Peter the Great, aimed at such domination. France, since the

MEHEMET ALI (1769–1849), recognized by the treaty of London as first hereditary pasha of Egypt.

Napoleonic conquests in Egypt, had wished to expand in that direction ; Great Britain did not wish any other power unduly to dominate or expand. Russian control of the Dardanelles was to be resisted at all costs.

The powers, acting in concert, each watchful of the others, intervened with an offer to Ibrahim which he rejected. Thereupon the British fleet seized Acre, while Syria, which had no love for Mehemet, rose for the sultan. As Napoleon's action had formerly been paralysed by his failure to capture Acre, so Ibrahim was now paralysed by the British seizure of it. Mehemet surrendered his claim on Syria in the treaty of London, 1841, while retaining his position as hereditary pasha of Egypt. The four powers participated in the treaty. This time, however, it was palpably Britain, not Russia, which had saved the sultan ; and Britain, not Russia, became the predominant influence with the Sublime Porte, as the government of Turkey was then called. In what was now becoming known as the Eastern Question, cordiality between Russia and Britain was impossible, owing to Britain's growing conviction that the tsar's real object was the acquisition of India.

LESSON 19

Europe's Year of Revolutions

THE year 1848 was the year of revolutions. Beneath the surface Italy was seething with hostility to Austrian domination, and the Sicilies with hatred of their Bourbon monarchy. No one, however, suspected that revolution was again imminent—still less (and least of all the French government) that the first outbreak would be in Paris.

LOUIS NAPOLEON (1808–73). Nephew of Napoleon I, he became French president and made himself emperor.

Nevertheless, in February 1848, without warning, the Orleans monarchy died, it may be said, of dullness. King Louis-Philippe abdicated in his turn, and fled to England. The spread of the Industrial Revolution from England to Europe had revived in the city proletariat the spirit of Jacobinism in the new form of socialism—hostility of labour to capital, not to the aristocracy—but this had no hold except in cities. The revolution was carried through by the bourgeoisie partly because Louis-Philippe was showing indications of reversion to absolutism, but much more because the whole country was weary of the drabness of the government and the secondary part it played in Europe. Self-constituted committees proclaimed the Republic and summoned a National Convention, which set about shaping a new constitution. In December, Louis Napoleon Bonaparte, nephew of Napoleon I and son of his brother Louis, sometime king of Holland, was elected by enormous majorities first president of the Second Republic.

Within three weeks of the fall of the French monarchy, revolutions with every variety of motive were in progress over the greater part of Europe, and half the governments had either collapsed or seemed on the verge of doing so. The duchies of Slesvig and Holstein, attached to the Danish crown, were demanding separation ; all over Germany the princes were promising or granting constitutions, Frederick William IV of Prussia taking the lead and posing at the same time as the champion of German nationalism and unity, to be attained through the establishment of a constitution for the German Confederation, to be drawn up by a Pan-German parliament which assembled at Frankfort-on-Main in May. Within the Austrian empire, Vienna, the German capital, demanded a constitution for Austria proper ; the liberals obtained control of the city, and Metternich fled to England. The Hungarian Diet, led by the nationalist Louis Kossuth, demanded autonomy not only for Hungary but for the Czechs in Bohemia and for the southern Slavs. It went on to formulate its proposed constitution in the March Laws.

Louis Kossuth (1802–49), led the Hungarian rising in the year 1848.

Meanwhile the Young Czechs (nationalists) gained control in Prague. Vienna for the time sympathised, and early in April the panic-stricken emperor Ferdinand promised the concession of all demands except those made by the south Slavs, which were incompatible with those of Vienna and Hungary.

In Italy Pope Pius IX had distinguished himself by liberal measures in the states of the Church ; Ferdinand II, king of Naples, was now frightened into granting a constitution, as Charles Albert, whose sympathies were liberal and nationalist, had already done in Piedmont.

But in Italy the condition of any real progress was the emancipation of the whole peninsula from Austrian domination. Charles Albert accepted the leadership and marched into Lombardy which, with Venetia, rose against Austria.

Italy rises against Austria

But here the Austrian government had an able commander-in-chief, Marshal Radetzky. He concentrated his troops in the strategic area known as the Quadrilateral, and waited his own moment ; while Charles Albert, whose gifts were those of a man of peace, not of war, also waited, till irritation at his inaction and mistrust of his leadership grew among the Italians, who were for the most part ardent republicans.

Meanwhile the Pan-German parliament met at Frankfort, and began by proposing to include Bohemia among the German states, which was the last thing the Czechs desired. The emperor Ferdinand at Vienna, on the other hand, issued a constitution which exasperated instead of satisfying all the revolutionary forces. Vienna rose, the emperor escaped hastily to Innsbruck, and the Viennese set up a provisional government for themselves.

Rehabilitation of the Hapsburgs

The Czechs replied to the Pan-Germans at Frankfort by calling a Pan-Slav conference whereby they alienated Vienna and the considerable body of German constitutionalists in Prague itself. Prince Windischgrätz, the commander of the imperial troops, saw his opportunity, and, on his own responsibility, without orders, seized Prague in June and took control as a military dictator in Ferdinand's name, resistance being out of the question. The Hungarian government, placed in control of the south Slavs, who detested Magyar even more than German domination, nevertheless set a Croat, Joseph Jellachich, in command of its army ; whereon he declared himself to be acting for the imperial government, which made haste to accept his services. Then in July Radetzky from the Quadrilateral attacked Charles Albert's forces and defeated them heavily at Custozza. Thus in two months the tables had been turned in favour of the imperial government in every quarter.

FRANCIS JOSEPH (1830–1916), creator of the "dual monarchy" of Austria-Hungary.

Before the end of the year the reversal had gone much further. Radetzky in Italy, being master of the situation, suspended hostilities under an armistice, while dissensions weakened the Italians. The Pope, dismayed at the course of the revolution and by the assassination of his liberal secretary Rossi, abandoned liberalism and escaped to the court at Naples, where Ferdinand II had cancelled the constitution and recovered his ascendancy, crushing the Sicilian rebels with a vindictive savagery which earned him the nickname of "Bomba" and caused the Bourbon family to be more bitterly execrated than ever.

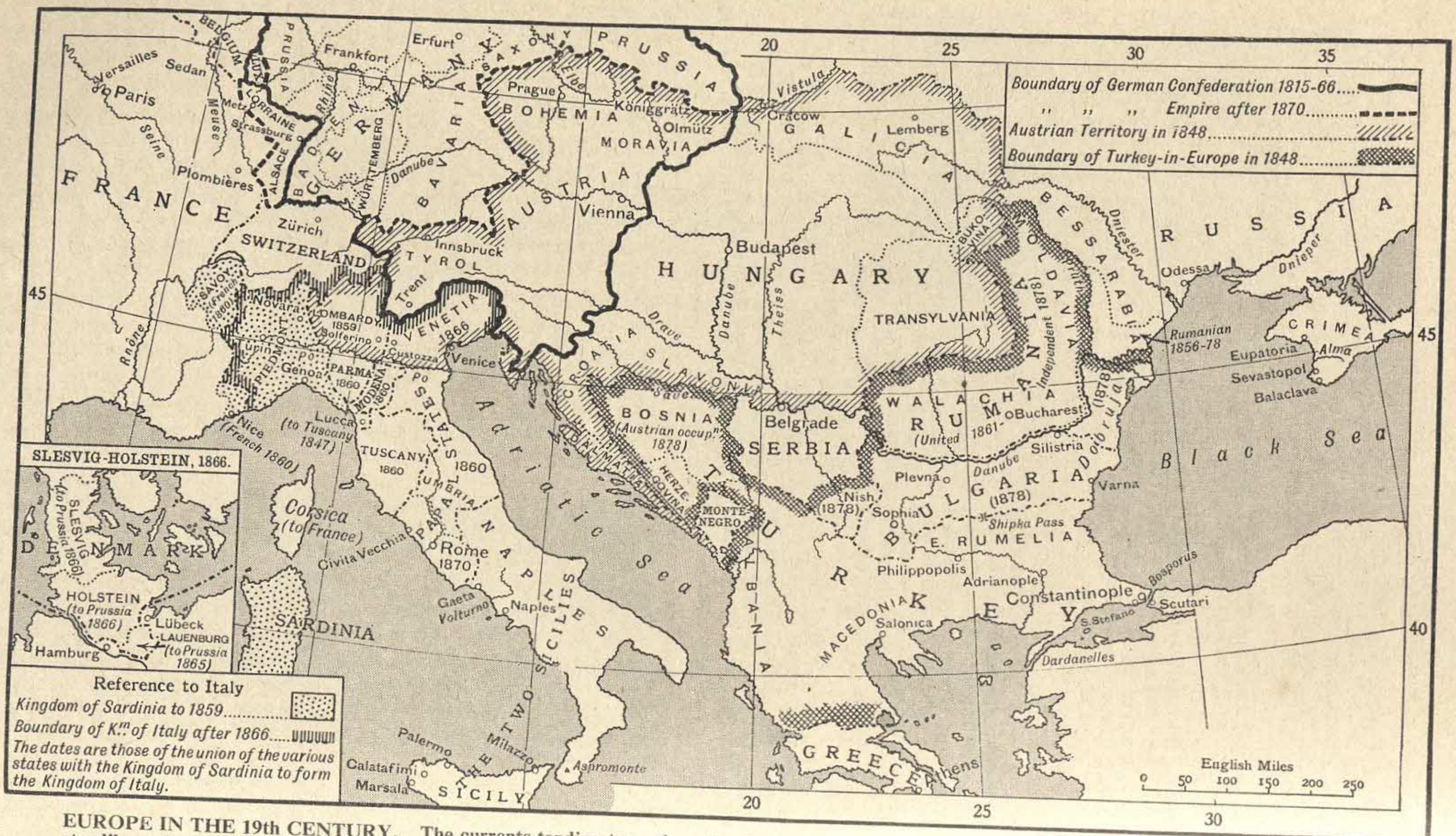
VICTOR EMMANUEL II (1820–78) of Sardinia-Piedmont became king of a united Italy in 1861.

Meanwhile matters had not gone too smoothly in Vienna, and Ferdinand abdicated in favour of his nephew Francis Joseph (1830–1916). Windischgrätz was master of Bohemia ; Hungary was completely isolated. It was announced that a new constitution for the whole of the Austrian empire was to be promulgated. Hungary replied by refusing to acknowledge the new "king" till he had sworn to the Hungarian constitution.

In Germany the Pan-German movement was breaking down ; the Frankfort parliament had elaborated a constitution, but its decisions had no binding powers behind them, and Frederick William in Prussia had deserted the cause by first intervening on behalf of Slesvig-Holstein and then admitting the Danish king's claim, following this reversal of policy by setting up a reactionary ministry in Prussia itself.

Accession of Victor Emmanuel

Before the autumn of 1849 the victory of reaction was complete. In Italy Charles Albert challenged Radetzky again, only to be hopelessly defeated at Novara in March. Rather than sign an ignominious peace he abdicated in favour of his son Victor Emmanuel (1820–78). The Austrians gave the new king his choice of accepting the status of a vassal, or of paying the penalty of refusal in the shape of armed



EUROPE IN THE 19th CENTURY. The currents tending towards national unity among the European states in the first half of the 19th century steadily gathered volume and produced a flood of violence that caused the year 1848 to be called the Year of Revolutions. This map illustrates the European state system as it evolved between that year and 1878, when Turkey lost much of her Balkan realm by the terms of the treaties signed at the Congress of Berlin called by Bismarck. The gradual growth of Italy under the leadership of Victor Emmanuel and Cavour may be followed by means of the dates appended to the successive additions; Alsace and the part of Lorraine ceded by France to Germany in 1871 after the Franco-Prussian War are specially marked; and an inset map shows the territory lost by Denmark to Prussia in 1866.

occupation of Piedmont, coupled with the exaction of a heavy indemnity. He had the courage to choose the harder course. Florence and Rome, which had both declared themselves republics, remained defiant. The French president tried to intervene, without pleasing either side ; the French forced their way into Rome and restored the Pope ; Radetzky had completely subjugated Lombardy and Venetia.

Defeat of Hungarian Rising

The Hungarians, on the other hand, inspired by Kossuth and led in the field by their brilliant guerrilla commander Görgei, made so stout a resistance, with overwhelming odds against them, that the issue seemed doubtful till the imperial government appealed to the tsar for aid. The Russian hosts overwhelmed the Magyars by sheer weight of numbers, and left them to the mercy of the Austrians, Nicholas having done what he conceived to be his duty in restoring despotism.

The scheme of German union collapsed. It was obvious that a Pan-German union must include Austria proper but exclude the non-German portions of the Austrian empire ; to this the Austrian imperial government would not assent. The Frankfort parliament proposed to offer the crown of a German union, excluding Austria, to Frederick William ; he rejected the offer. Fresh proposals were made, all of which came to nothing. The old constitution of the German Confederation, which had never been dissolved, continued in force.

In France the Republic expected Louis Napoleon as its president to emulate his mighty uncle, whom, though lacking the necessary genius, he nevertheless sought indeed to imitate. As representative of the Napoleonic Idea he must convince the French people that he was the representative of stable and popular government at home, of glory and achievement abroad. His intervention in Italy had neither conciliated the clericals nor satisfied the democrats ; now he sought to increase his own popularity by posing as the champion of democratic rights which the Chambers were seeking to curtail, thereby alienating the Chambers, in which a three-to-one majority was required to sanction his re-election as president in 1851. When the time came, the majority was large but not large enough. But he had prepared for the *coup d'état* that, following precedent, was to secure him control in defiance of the Chambers. The military chiefs were in the plot. He called for a law reviving universal suffrage ; the Assembly rejected it. On the night of December 1 the leaders of the opposition were arrested ; in the morning soldiers were patrolling the streets of Paris. Resistance was stamped out, and a plebiscite triumphantly returned the "Prince President" to office. Twelve months later, in December 1852, another plebiscite made him Emperor of the French with the style of Napoleon III.

LESSON 20

The Unification of Germany and Italy

DURING the French Second Empire (1852–70) under Napoleon III there came a series of international wars, the first being the Crimean War. The recognition of Greek independence in 1829 still left under Turkish rule not only many Christians but the Holy Land and Jerusalem itself. Some twenty years later a dispute arose between Roman Catholic and Orthodox monks in Jerusalem over the custody of some of the Holy Places. Napoleon III championed the Roman Catholic claim ; Nicholas I, tsar of Russia, championed the Orthodox. The dispute was decided against the wishes of Nicholas, who in June 1853 sent troops into the trans-Danube provinces, demanding not only a revision of the Jerusalem decision but the right of protecting all Christians under Turkish rule.

The Porte, reckoning on Britain's support, refused to submit to Russian dictation. Nicholas did not realize the hostility of British public opinion to the suspected Russian designs on India and to the more evident Russian designs on Constantinople. In France the war spirit was as high as was distrust of Russia in Britain.

The Turks held up the Russians at the Danube. A Russian squadron sank the Turkish fleet at Sinope in November. In March 1854 France and Great Britain allied themselves with Turkey. French and British troops joined the Turks at midsummer 1854 ; the Russians fell back across the Prut, and Nicholas would probably have assented to any terms that were not humiliating. But Napoleon wanted something more Napoleonic, and the British were determined on drastic action to counter the Russian menace ; so the two powers and the Turks landed an expeditionary force in the Crimea.

War in the Crimea

The allied organization was at first insufficient for the conduct of the siege of Sevastopol. The harbour was blockaded, but on the land side the investment could not be made complete. Incidents of the siege were the famous Balaclava charges ; the battle of Inkerman, fought in a thick fog ; the terrible privations throughout the winter ; the arrival of an Italian contingent to assert Sardinia's European status; the new organization of the base hospitals at Scutari, on the Bosporus, which the world owes to Florence Nightingale, who arrived with her band of nurses to inaugurate the activities out of which arose the Red Cross; and the capture of the Malakov fort by the French, which ensured the fall of Sevastopol, after a year's siege, in September 1855.

Florence Nightingale (1820–1910), sent to Scutari in 1854 to take charge of the British sick and wounded.

Meanwhile Nicholas died and was succeeded by his son, Alexander II, who more resembled his idealist uncle, Alexander I, than his despotic father. Alexander's desire was for peace. The allies had won all they could hope to win and the war was ended by the treaty of Paris, March 1856; Sardinia was represented at the peace conference. Turkey, always ready to pledge herself to reforms, was guaranteed full sovereignty within her dominions; Wallachia and Moldavia were freed from Russian suzerainty; warships were excluded from the Black Sea, which was opened to commerce. Napoleon was satisfied with the prestige he had acquired, and Great Britain with the frustration of Russia's supposed intentions. Union of Wallachia and Moldavia to form Rumania followed in 1861.

War of Italian Liberation

Charles Albert had failed as the champion of Italian aspirations, but his attempt and its failure had shown that emancipation from Austrian domination was the condition of escape from despotism, that disunited action could never be successful, and that united action was possible only under Sardinia's leadership.

CREATORS OF UNITED ITALY. Count Camillo di Cavour, 1810–61 (left), became prime minister in 1852 and retained this post with short intervals until his death. Giuseppe Mazzini, 1805–72 (centre), ardent advocate in exile of Italian freedom; his republicanism would not allow him to support the kingdom of Italy. Giuseppe Garibaldi, 1807–82 (right), joined Mazzini's Young Italy movement and later led an army of irregulars in the campaigns that united Italy.

To his courageous and popular successor, Victor Emmanuel II (1820–78), and Victor Emmanuel's great prime minister Count Cavour (1810–61), it was also clear that—however strongly idealism or sentiment might resent the fact—Austria could not be expelled from the Italian peninsula without foreign aid.

The only foreign power whose self-interest might induce it to give Sardinia active aid against Austria was France; Napoleon would be ready enough to combat Austrian influence in Italy, but not to help in creating a powerful and united Italian state; and for whatever aid he might give he would demand his price. Cavour, however, had strengthened a sympathetic public opinion for Sardinia both in France and England by joining them in the Crimean War when Austria had held aloof; he was able to strengthen it further by giving prominence to the Italian grievances at the subsequent peace conference. In 1858 he came to a secret agreement with Napoleon. The conditions of French aid were that Austria must appear the aggressor, that the outcome of success should be an Italian confederation under the Pope's presidency, and France's reward the cession of Savoy and Nice.

Cavour had at least succeeded in exciting the interest of all Europe in the national feeling seething in Italy since the exiled Giuseppe Mazzini (1805–72) had inspired and founded the "Young Italy" movement in Marseilles in 1831. Giuseppe Garibaldi (1807–82) had joined this movement in 1834. Both Sardinia, where Garibaldi was raising troops of volunteers, and Austria were clearly preparing for war. Austria, by demanding in April 1859 the disarmament of Sardinia, assumed the role of aggressor. France thereupon declared war. Austria was defeated at Magenta and Solferino and acceded to terms offered by Napoleon at Villafranca (July 11), where he virtually deserted Sardinia. By the treaty of Zürich, November 1859, Austria ceded Lombardy but not Venetia to Sardinia. A number of minor Italian states rejected their rulers and voted themselves by plebiscite into the kingdom of North

Italy. Cavour's fears that Napoleon might intervene to arrest this process led him to offer Savoy and Nice to France if Napoleon would accept the adherence of the Italian states to Victor Emmanuel.

The bargain was struck, and acted on after it had been duly shown by plebiscite that Savoy and Nice favoured union with France.

Garibaldi in Sicily

Then on his own responsibility and against the orders of the official government, the brilliant Garibaldi organized the volunteer expedition of the thousand "red shirts" which deprived Francis II, the successor of Bomba, of the throne of the Sicilies. Within two months of his landing in the island in May 1860, Garibaldi was master of Sicily and its elected dictator. He crossed to Italy, and his march on Naples was a triumphal procession. No one could tell what he would do next when he had finished with Francis. If he proclaimed a Sicilian republic it would be dangerous; if he marched on Rome where the Pope still ruled, it would be fatal. Cavour must have troops on the spot.

Italy Achieves Unity

On the plea that the foreign troops in the Pope's pay were a menace, Victor Emmanuel entered the papal states in arms; the provinces by plebiscite transferred themselves to the northern kingdom. But the "Patrimony of St. Peter" was left intact to the Pope. Meanwhile, Garibaldi was in Naples and Francis II was holding out at Gaeta. Victor Emmanuel advanced into Neapolitan territory. Would he have to fight Garibaldi? They met face to face; and the Liberator hailed him as king of Italy. Both the Sicilies had already declared for union; Gaeta was occupied in January 1861.

OTTO VON BISMARCK (1815–98), Prussian premier 1862, and first German chancellor 1871.

Only Venetia and Rome remained outside the new kingdom of Italy when it was formally proclaimed on March 17, 1861, in which year Cavour died, and baron Ricasoli (1809–80), an able statesman who had laboured for the unity of Italy, succeeded him at the head of the ministry.

He it was who modelled the organization of Italy on French lines—dividing it into provinces, each with its prefect, under the minister of the interior.

William I and Bismarck

WILLIAM I (1792–1888), king of Prussia, proclaimed first German emperor in 1871.

Germany in 1851 had reverted to the system of the German Confederation, in which the princes were for the most part dominated by the influence of Austria. Two factors contributed to a change which transferred hegemony to Prussia. One was the Prussian Zollverein or customs union into which most of the states had been drawn since its initiation in 1819, creating for them a common bond of commercial interests with Prussia as the senior partner, while Austria stood outside; the other was the substitution in 1857 for the erratic Frederick William IV, whose health gave way completely, of his brother William (1797–1888), first as regent and then, from 1861, as king of Prussia. For William found in Otto von Bismarck (1815–98) the minister who in the course of a few years made Prussia the first among the European powers by unscrupulous but extremely skilful statecraft. Bismarck meant himself to direct William, William to rule Prussia, Prussia to rule Germany, and Germany to rule Europe.

Seizure of Slesvig-Holstein

The revival of the army, which a century previously had been the most efficient in Europe, was in William's estimation the first essential. It was only by the help of a minister who was ready to override the Prussian constitution that the necessary revenue could be raised. Bismarck was the man to do it; the army was organized under von Moltke (1800–91) and von Roon (1803–79). The next step was to reconstruct the Confederation, with Austria excluded. Austria in 1863 propounded a re-organization scheme of her own. Prussia rejected it, but proposed a freely elected federal parliament. Then Austria and Prussia jointly took up the old Slesvig-(in German, Schleswig) Holstein question, invaded Denmark, 1864, and forced her to hand over the duchies, the respective administration of which the two powers appropriated.

Prussia had now tested her military machine. Bismarck required only security from adverse intervention before scraping the necessary quarrel with Austria. He duped Napoleon into believing that it would pay France to encourage a contest between Prussia and Austria ; he made a private pact with Italy that her opportune intervention should be rewarded by the acquisition of Venetia. Then he quarrelled with Austria over the position in Slesvig-Holstein. Austria referred the question to the diet of the Confederation. Bismarck demanded that a new constitution should first be established—excluding Austria—and a federal parliament called. Prussian troops entered Austrian-held Holstein ; Austria called on the Confederation to assert its authority in arms ; and Prussia withdrew from the diet, June 14, 1866.

The Seven Weeks War

Next day war was declared. The German princes were with Austria, but the Prussian army soon vanquished North Germany and Hanover ; although the Austrians defeated the Italians at Custozza, both Austrians and Bavarians were overwhelmed on July 3 at Königgratz (or Sadowa), and the victorious Prussian troops occupied the German principalities. The Seven Weeks War was over before Napoleon could intervene ; the peace of Prague was signed, August 23. Venetia was ceded to the Italians, and Austria was permanently excluded from the German Confederation.

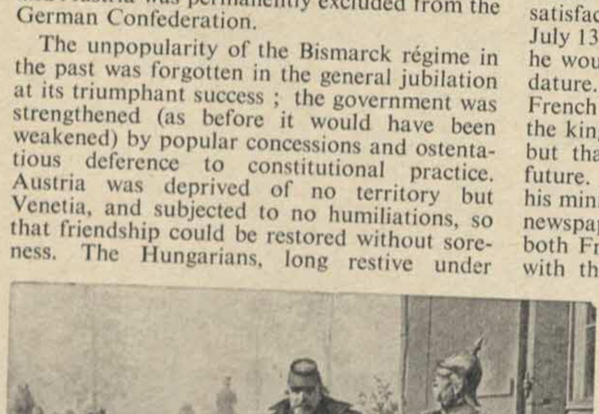
The unpopularity of the Bismarck régime in the past was forgotten in the general jubilation at its triumphant success ; the government was strengthened (as before it would have been weakened) by popular concessions and ostentatious deference to constitutional practice. Austria was deprived of no territory but Venetia, and subjected to no humiliations, so that friendship could be restored without soreness. The Hungarians, long restive under Austrian rule, had established a claim on the imperial government by their leaders' judicious attitude at this crisis, and in 1867 an arrangement was made which created the dual monarchy of Austria-Hungary, each country accepting Francis Joseph as ruler but enjoying distinct administrative systems, one German, the other Magyar, and having a common government, supreme in war, finance, and foreign affairs.

France had failed to snatch any advantage out of these great events. From this time Bismarck was rather preparing than awaiting the opportunity to deal with the remaining obstacle to Prussian ascendancy—the rivalry of France, whose unfailing policy since the days of Richelieu had been prevention of the consolidation of Germany ; yet the opportunity was not, in fact, of his making. It was provided by Spain, which ejected Queen Isabella and sought a foreign prince to whom her crown might be offered. One possible candidate was a prince of a junior branch of the house of Hohenzollern. Here was a menace to French influence in the Peninsula. King William and Bismarck were at odds on the question. Prince Leopold's acceptance would almost certainly bring on the war which Bismarck desired. The offer was made, but rejected by Leopold on July 12, 1870.

But Napoleon's hand, to Bismarck's deep satisfaction, was forced by the war party. On July 13 he demanded a pledge from William that he would in no event support Leopold's candidature. There was an interview between the French ambassador and King William at Ems, the king declaring that the incident was closed, but that he could give no pledges as to the future. His telegram reporting the interview to his minister was published that night in German newspapers, but in a condensed form, which set both France and the whole of Germany ablaze with the war fever. Napoleon declared war. South as well as North Germany threw in its lot with Prussia.

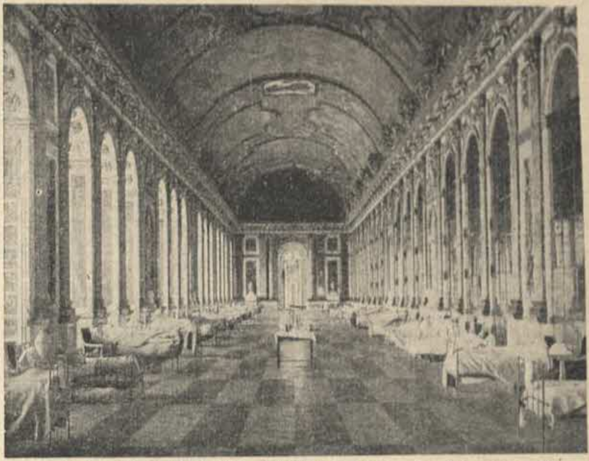
Franco-Prussian War

The fighting began on August 2 at Saarbrücken. Then in the course of a fortnight the Germans won a series of costly victories at Wörth, Colombières, Mars-la-Tour, and Gravelotte ; they shut up Bazaine with 170,000 men in Metz and drove MacMahon to join the emperor at Sedan, where, after fierce resistance, on September 1 Napoleon surrendered with his whole force, and the second French empire vanished. Paris proclaimed the Third Republic with a government of national defence under General Trochu, Jules Favre, and Léon Gambetta. The Republic was willing to treat, but not to surrender territory. Bismarck demanded Alsace



AFTER SEDAN. Germany was unified by wars fought under Bismarck, her "Iron Chancellor," who is seen here after the French defeat at Sedan discussing the position with the captured emperor Napoleon III.

and Lorraine. On September 19 the siege of Paris began. On the 27th Strasbourg fell: a month later Bazaine surrendered Metz together with his army. Meanwhile, Gambetta escaped from Paris in a balloon and organized the government from Tours. The struggle was maintained by raw levies fighting desperately against the mightiest military machine yet known: since 1866, Moltke and Roon had been organizing the general German army up to the Prussian standard of efficiency. There could be only one result. The war party had rushed the French people into a conflict for which they were totally unprepared. The Germans had vanquished the French regular army; fervid patriotism and dauntless courage could not hold their own against perfect training and consummate organization. On January 28, 1871, Paris was starved into capitulation; the last forces in the field had already been crushed, or interned in Switzerland. The victors dictated the terms of the armistice.


HALL OF MIRRORS, VERSAILLES. In this room of Louis XIV's palace William I was proclaimed first German emperor, January 18, 1871; here representatives of a defeated Germany signed the Treaty of Versailles, June 28, 1919.

Other important events had taken place since Sedan. The Italian kingdom regarded Rome as its rightful capital, but there the Pope, under the aegis of Napoleon, was temporal as well as spiritual sovereign. After Sedan Victor Emmanuel did not hesitate to march on Rome (September 1870) and make it his own secular capital, while the Pope, no longer a temporal sovereign, was confined to possession of the Vatican.

LÉON GAMBETTA (1838–82) proclaimed the Third French Republic in 1870 and became minister of the interior and of war.

During the Franco-Prussian War the states of the South German Confederation were successively coming into the North German; by the end of the year they had all agreed to transform the president of the North German Confederation, the king of Prussia, into the hereditary German emperor, and as such William I was acclaimed on January 18, 1871, in the Hall of Mirrors at Versailles.

Germany—or Bismarck—dictated the terms of the treaty with France, concluded at Frankfort-on-Main on May 10, 1871; its main feature was the cession to Germany of Alsace and nearly a third of Lorraine; German troops were to remain in Paris till France should have paid off an indemnity of £200,000,000. The French showed a power of recovery which astonished the world, though it was not till near the end of the decade that France was able to resume her place in the front rank of the European powers. The government and administration needed complete re-organization, and for some time it was uncertain whether the provisional Republic might give way to a monarchical restoration, a possibility frustrated by the division of the monarchists between the rival claims of the three dynasties of Bourbon, Orleans, and Bonaparte. (The hopes of the Bonaparte family were eclipsed in 1879 with the death during the Zulu War of Napoleon III's son, the Prince Imperial. To-day the Comte de Paris combines the claims of Bourbon and Orleans, and is regarded as king by a small royalist party.

Bismarck's policy had turned France into an enemy irreconcilable but for the present powerless; to keep France powerless was therefore with him a primary object. Russia was powerful and might become an enemy if Russian interests should clash with those of Germany. Austria, having accepted separation from Germany, had no interests antagonistic to those of Prussia, and was desirable as a powerful ally. Unison among the three emperors would guarantee the peace of Europe and the consolidation of the German imperial system. Italy was not yet consolidated and Britain was unlikely to be attracted either to Russia or to France. A mutual understanding between the emperors—the informal "Dreikaiserbund"—was the result. But before long Russian and Austrian interests clashed in the troubled Balkan peninsula.

LESSON 21

American Nations in the Making

When the wars with Napoleon I were concluded in 1815, Brazil, the largest country in South America, was still attached to Portugal. The rest of Latin America, including Mexico, was attached to the restored Spanish monarchy ; the people—Spaniards, Creoles, half-castes, Africans, and aboriginal Indians — were ruled by governors sent from Spain.

Brazil effected a peaceful change. From 1808 till 1821 Rio was the residence of the Brazilian court, and after the king's return to Portugal, his son Pedro, the Portuguese crown prince and regent of Brazil, declared himself emperor of an independent Brazil (1822) and resigned the Portuguese succession in favour of his daughter Maria da Gloria on his father's death in 1826.

SIMON BOLIVAR (1783–1830), born in Carácas, (Venezuela), led the Spanish colonies in revolt against Spain.

The Spanish crown was the one link which held together the scattered dominions of Spain. During the Peninsular War, the Spanish colonies in America began to consider the advantages of independence, though traditional royal authority continued to prevail for some years. Spanish American emancipation was effected by a series of revolutions which swept away existing institutions. With the fall of the monarchy in Spain the separatist and regional tendencies characteristic of Spaniards were increased in South America by the geographical distances and large areas of the Spanish dominions there. Emergency governments were set up in every Spanish-American capital to replace fallen authority, and to resist French aggression. These efforts at local self-government led to the creation of independent states.

In the temperate regions of Buenos Aires and of Chile the revolution was carried through by fairly constitutional methods. In 1816 the emergency governments formed in 1810 abandoned the theory of dependence on Spain ; Argentina came into existence as a republic, and in 1817 the Argentine general San Martin led his army over the Andes to liberate Chile from invading Peruvian royalists and established her independence. A Chilean war fleet, under Thomas Cochrane (afterwards Lord Dundonald), and chiefly manned by English sailors, landed Chilean and Argentine forces under San Martin in Peru, where they defeated the royalists.

In tropical Latin America, violent turmoil preceded emancipation. Carácas was twice retaken by royalists. Bolivar, the Liberator, enlisted a British legion in England and Ireland, and in a series of astounding campaigns defeated the Spanish royalist forces. Cochrane had already cleared the Pacific of Spanish ships. In 1824 Bolivar's army was victorious at Ayacucho, and the independence of Spanish South America was secured, though the various states acquired little stability until the end of the 19th century.

The Americas were not practically involved in the political complications of Europe, especially after the enunciation in 1823 of the Monroe doctrine. For the Americans international questions meant disputes between American states with which European states had nothing to do, except so far as the security of the lives and property of their own nationals might be involved. Meanwhile the attitude of George Canning, British foreign minister, had averted the complication of French aid for the Spanish scheme of reconquest ; in 1825, Great Britain recognized the independence of Buenos Aires (Argentina), Colombia, and Mexico. Venezuela was established as a republic in 1830. Bolivia and Peru had separated before the death of Bolivar in that year. Notwithstanding revolutions, strife and political set-backs, freedom of commerce and of intercourse with Europe now steadily increased. The influx of European, and particularly of British, capital, together with the demand for South American raw materials, greatly aided development of the new states.

Affairs in Mexico

In Mexico, and the five small provinces of Central America, emancipation was delayed. When independence was acknowledged, these five provinces separated themselves from the Mexican republic and became the independent republics of Guatemala, Honduras, Salvador, Nicaragua, and Costa Rica. Mexico continued to be menaced by attempts at reconquest from the Spanish island of Cuba. In 1836 Texas seceded from Mexico, and became one of the United States of North America in 1845. Frontier questions led to war with the United States, 1845–48, during which Mexico was invaded and the capital occupied ; as a result, one-third of its nominal territory, northern California and New Mexico, was ceded by the treaty of peace to the United

States in return for a money payment. This opened up the westward expansion of the United States to the Pacific Ocean, with important effect on U.S. history and development.

After the recognition of the United States in 1783, that country had set up a federal authority for the Union which in certain respects was superior to the authority of the individual states. From the beginning there were conflicting views between the state governments and the federal government as to the extent to which the common authority could override state rights (that extent has steadily and inevitably increased down the years).

North and South in the United States

Social and economic traditions combined to draw a dividing line between the northern and southern states of the Union. The southern planters, often with a tradition of life as English gentry behind them, lived on large estates run by Negro slave labour in a subtropical climate. The northerners, most of them farmers or traders, had a Puritan tradition, and many of them had Puritanical religious convictions; they lived in a hard climate and neither required nor desired to use slave labour, so were not blinded to its moral obliquity by economic interest. Slavery was the established system of the south, and southerners found it easy to believe that it was a divinely-approved institution; in the north it was prohibited. But northerners recognized its existence in the south as a matter of state right.

ABRAHAM LINCOLN (1809–65), U.S. president 1861–65. His election in 1860 was the signal for the secession of the southern states.

Westward expansion in the middle of the 19th century gave the problem a new aspect. As fresh territory was occupied, new states were being formed: were they to be slave states, like those of the south Atlantic coast, or free states, like those of the north? Northern sentiment demanded that every new state formed should be free; the south claimed that the existing "Missouri line" dividing slave states from free should be extended westward between newly formed states. The abolitionists, northerners who demanded not only that all new states should be free but that the accursed thing should be rooted out in the south, were a strong though small body; their energetic propaganda reached its most telling expression in *Uncle Tom's Cabin*, published in 1852: Harriet Beecher Stowe, its author, had no first-hand acquaintance with the south when she wrote it. John Brown, most extreme of abolitionists, engaged in active border conflicts in Kansas; after a raid on the United States armoury at Harper's Ferry he was captured, convicted, and hanged for treason and murder in 1859. His name became a battle cry in the armies of the North.

American Civil War

On November 6, 1860, Abraham Lincoln, who abominated slavery, was elected next president of the United States, to take office on the following March 4. The South, convinced that its interests were doomed, decided that it was time to secede from the Union, and in February 1861 seven of the southern states (South Carolina, Mississippi, Florida, Alabama, Georgia, Louisiana, and Texas) drew up at Montgomery, Alabama, a constitution for the "Confederated States of America," and elected Jefferson Davis their president.

Lincoln in his inaugural address insisted that the contract binding the states of the Union together was irrevocable. Virginia, Arkansas, Tennessee, and North Carolina joined the seceding states. On April 12, 1864, the Confederates seized Fort Sumter, a federal arsenal in Charleston harbour, and the Civil War began. In the northern view the Confederates were rebels; in their own view they were fighting for states' rights and freedom from tyranny.

The immediate issue over which the war was fought, therefore, was not the abolition of slavery but the right of one portion of the Union to separate itself at will from the other portion. Europe, remaining neutral, recognized the South as de facto belligerents, not rebels. The war was fought between volunteer citizen armies, the southern Confederates being numerically much weaker, while the northern Federals had so much the stronger fleet that they were able to blockade the Confederate ports and cut off the commerce on which the South depended. Nevertheless, for a long time the balance of military success was with the South which, unlike the North, put all its forces into the field from the beginning.

At Bull Run, in Virginia, the first big battle, the Confederates were victorious; the following year, 1862, General Robert E. Lee put the northern troops to flight in the same neighbourhood, driving them back to Washington. But the South had no reserves, whereas the North could not only make good its losses but continuously multiply its armies. In January 1863

Lincoln proclaimed the emancipation of all slaves. In that summer the South met its decisive check in the great three days' battle of Gettysburg. In the campaigning of 1864, when Ulysses Grant had been placed in general command of the Federal forces, the southern armies under Lee were gradually enveloped ; in April 1865 the Confederate army was overwhelmed, and Lee was forced to surrender at Appomattox Court House, April 9, 1865. The war was finished ; slavery was no more, and the American nation was at last an established fact.

Five days later, while viewing a play with his family at Ford's Theatre, Washington, Lincoln was shot by J. W. Booth, a fanatical actor, and died the next morning, April 15, 1865.

LESSON 22

The Balkan Maze

The Sublime Porte failed to carry out the reforms promised in 1856 ; and in 1875 the two Christian provinces of Bosnia and Herzegovina rose against Muslim oppression. The Bulgarians joined them ; so did the Serbians and Montenegrins. The rising was suppressed with ferocity, 12,000 Bulgarian Christians being massacred ; and in April 1877 Russia declared war on Turkey. The Russians, with Rumanian support, advanced. They suffered a temporary check before Plevna ; but by March 1878 they were before Constantinople, and the Turks were forced to accept the treaty of San Stefano, which created a large autonomous Bulgaria under Russian protection.

"ABDUL THE DAMNED," the sultan Abdul Hamid II, reigned from 1876 till 1909.

It suited none of the other Great Powers that the Turkish empire in Europe should be under Russian tutelage, and war between Great Britain and Russia seemed imminent when Bismarck called together the Congress of Berlin, June 1878. The independence of Serbia, Montenegro, and Rumania was recognized (Rumania became a kingdom in 1881, Serbia followed suit in 1882). Bosnia and Herzegovina, nominally still under the sultan, were handed over to Austrian administration ; a much smaller Bulgaria than the tsar had planned was given a Christian governor but left under Turkish suzerainty, and still liable to pay tribute to the sultan. Peace had been preserved in Europe ; but none of the conflicting interests in the Balkans was satisfied.

Lord Beaconsfield, the British prime minister, went to the Berlin Congress determined that a limit must be put to Russia's claims in the Balkans. Whether his policy was or was not in itself wise, he carried it through triumphantly, defeating Russia all along the line, and claimed to have secured "peace with honour."

The Berlin Congress had been conducted under the presidency of Bismarck in the character of wholly disinterested friend of all the parties concerned, Germany having no stake at all in the Balkans. Nevertheless, it had materially increased the difficulties of his policy. His primary aim was to maintain a close accord between Germany and Russia on the one hand and Germany and Austria on the other ; a breach between Russia and Austria, especially one which might force Germany to side with one against the other, was therefore to be strenuously avoided. The Balkans provided a permanent area of possible friction. The Congress gave Austria the desired protectorate of Bosnia ; the Russian project had been balked, but Austrian friendship was more necessary than Russian to Bismarck, and he could not afford to placate Russia at Austria's expense. It suited him very well that hostile feeling between Russia and Britain, as possible allies of a permanently alienated France, should be intensified. The need to keep France isolated was, from the German point of view, imperative.

Anglo-French Rivalry in Africa

Any attraction between France and Great Britain was made the more improbable by the friction between the two powers engendered by the establishment of a British protectorate in Egypt in 1882. France's ambitions did not square with Great Britain's in Morocco either ; France and Italy had both been casting covetous eyes on Tunis which France, encouraged by Britain and Germany, annexed in 1881. Italian jealousy made it the easier for Bismarck to attach Italy, in spite of that country's traditional friction with Austria, to the informal league of the three emperors.

In Russia the revolutionary movement called Nihilism had developed. Alexander II, like Alexander I before and Nicholas II after him, was a visionary with high ideals, unaware that his power of action was circumscribed by tradition and by the cast-iron tyranny embodied in

ALEXANDER of Battenberg, prince of Bulgaria 1879, forced to abdicate 1886.

the bureaucracy of the tsardom. The effect of his reforms (he emancipated the serfs in 1861) had been destroyed by the agents who never intended them to succeed, and by the merciless iniquities of the law, and the "Tsar-Liberator" was murdered by the bomb of a nihilist in 1882. His son Alexander III was made more autocratic by this crime; all thoughts of reform vanished and the tyranny of the government and its officials became more grinding and ruthless than ever. Attachment to Germany cooled; things were not going well for Russia in the Balkans.

BULGARIAN PREMIER Stepan Nikolov Stambulov became virtual dictator in 1887.

The prince nominated to Bulgaria was another Alexander—of Battenberg—a kinsman of the tsar, who expected to find in him a subservient tool. The principality had an admirable constitution on paper; in practice, the tsar provided it with a Russian administration, while Bulgarian nationalism seethed. Just before the assassination of Alexander II the prince effected a *coup d'état*, suspended the constitution, dismissed the Russians, and governed through Bulgarian ministers—to the great joy of his people and the wrath of the tsar. Two years later, 1883, he was able to restore the constitution. Then in 1885 Rumelia rebelled against its Turkish governor, and offered itself to Bulgaria. Alexander accepted the offer; Serbia was at once up in arms, demanding an equivalent. There was a short war, Bulgaria being victorious at Slivnitza; but Austria intervened to stop the fighting, while the Porte offered Alexander the governorship of Rumelia under its own sovereignty.

Then occurred a curious episode. Russian agents kidnapped the prince, carried him over the border, and forced him to abdicate, 1886. Bulgaria under the dictatorship of Stambulov, the indomitable Bulgarian minister of Alexander, stood defiant—Russia having no plausible case for intervention—and accepted a new prince, 1887, Ferdinand of Saxe-Coburg, who for a time was content to reign while Stambulov governed. The remnant of profit in the Balkans that Russia had saved from the victory over Turkey when the Berlin treaties took the place of that of San Stefano had thus been thrown away by overbearing interference. The Balkan states were still seething with their jealous antagonisms, and Serbia was rent by dynastic rivalries. Bosnia was, however, enjoying unwonted prosperity under Austrian rule, while Turkey, under Abdul Hamid II, held firmly to the time-honoured policy of propounding programmes of reform which were always left unfulfilled.

In 1888 the aged emperor William I died; his son Frederick, already a dying man when he ascended the throne, followed him to the grave three months later. Bismarck's day was over. In 1890 the man who had created the German empire was retired into private life. The new autocrat, William II (emperor 1888–abdicated 1918), had no use for a tutor in statecraft. William II inaugurated his reign by a departure from precedent which appeared at the time to be eccentric rather than significant. He paid a state visit to the sultan, which no other European monarch had done before. Actually, it meant that he had adopted a new outlook on the East and eastern questions. The development of German influence or power in Asia was an idea so new that it was not readily assimilated by the world at large, since the method adopted was that of "peaceful penetration" by way of commerce, not the blatancy of the mailed fist.

One at least of the aims of Bismarck's European policy was conspicuously outworn. In 1891 Russia and France were manifestly drawing together. Austria and Germany were drawn together even more closely, having no divergent interests. The "Dreikaiserbund" was dead; Europe was settling down to a very uneasy equilibrium between two pairs of powers, each pair in constant dread of aggression by the other. The peace was not likely to be broken so long as both groups felt the chances of decisive victory to be uncertain, and neither could count on active support from any other power. The isolation of Great Britain from continental quarrels was at this period complete.

THE 99-DAYS GERMAN EMPEROR. Frederick, father of William II.

LESSON 23

The Partition of Africa and Rise of Japan

THE magnitude of the British empire was a constant source of jealousy to the continental powers. During the 1880s Europe generally — including France, where the idea was by no means a novelty—had awakened to the existence of vast unexploited territories in Africa which were in danger of being absorbed by the British unless other countries made haste to secure a share for themselves. Great Britain was already in control of Egypt, and sovereign in South Africa, except in those areas which had for centuries belonged to Portugal.

A scramble for African territories began, Germany for the first time taking active part in spite of the coldness with which Bismarck—concentrating on European hegemony—contemplated colonial expansion. France, having foiled Italy in Tunis and been foiled by the British in Egypt, annexed Madagascar, which attracted no other power ; King Leopold of the Belgians secured possession of the Congo ; France planted a colony hard by ; Germany occupied territory in both East and West Africa.

Partition of Africa

A series of treaties partitioned Africa into "spheres of influence" consummated by an Anglo-German agreement in 1890 which the colonising parties in both countries regarded as a miserable surrender on the part of its own government. (At this date Lord Salisbury's cession of Heligoland for Zanzibar to Germany also met with adverse criticism.) French sentiment received a shock in 1898 when Kitchener with British and Egyptian troops wrested the Sudan from the Khalifa by the Omdurman campaign. The Sudan had been abandoned in 1885, and Kitchener politely declined to recognize the claim to prior occupation made by a party of French who had reached Fashoda. The French government, recognizing that there was no sound case for protest, declined to make the incident a cause of serious quarrel. The anti-British sentiments of several European nations were clearly demonstrated by the sympathy accorded to the Boers when the South African War broke out at the end of 1899, but the sympathy did not lead to active aid.

The Far East

Eastern Asia seemed to the West to offer a hitherto unworked field for exploitation, but on the other hand the idea was gaining ground that China, with its enormous population and possible resources, might be awakening and, awake, might become not a prey but a menace to Europe—that a "yellow peril," against which the West must arm itself, was in sight.

Japan, induced by the U.S. Commodore M. C. Perry to sign a treaty in 1854 opening her ports to American trade, had awakened from her prolonged trance of medievalism. Headed by the feudal nobility, the Samurai, and by the young mikado—to whom on his accession in 1868 the Shogun Kokei deliberately resigned the imperial functions, thus ending the system of rule by hereditary military leaders appropriated to the Shogunate in the 13th century—initiated and carried through an unprecedented revolution, abolishing the old feudal system. A rebellion of malcontents and irreconcilable conservatives in the Satsuma clan was suppressed.

Feudalism Ended in Japan

The mikado began to reconstruct the Japanese polity from top to bottom, re-organizing army and navy on the basis of a scientific study of European methods and principles, and adopting those institutions to which Europe would appear to owe its competitive superiority over every Eastern people with whom it had come into conflict. In 1871 the ancient clans were abolished by imperial decree and prefectures created instead. At the same date the feudal chieftains and court nobility became one class, while the warriors or clansmen (the Samurai) were merged in the new gentry class and forbidden to wear arms. These changes were voluntary on the part of those chiefly concerned.

Chinese Ejected from Korea

The whole Far Eastern question was forced upon the attention of European statesmen by a war between China and Japan in 1894 in which, to the general amazement, the Chinese were ejected from Korea, over which they had claimed suzerainty, and were thoroughly defeated by the organized and efficient Japanese.

But if Japan were allowed to reap the natural fruits of victory, the Russians, who throughout the 19th century had been pushing their suzerainty steadily eastward in Asia, would be frustrated in their desire to reach the ice-free ports on the north Pacific, for those ports would pass into Japan's hands. Under pressure from Russia and France, with support from Germany, Japan reduced her territorial claims to a minimum, content for the time being to have established a footing on the mainland, and a title to be treated as an equal by the European powers. These powers generally now began to scramble for concessions from the Chinese.

Then within China broke out the Boxer Rebellion, 1900, inspired by hate of foreigners at large and all their ways, connived at if not encouraged by the dowager empress, the real ruler of China. Two German missionaries were murdered; anti-foreign riots took place; the government did nothing. The German minister, Baron von Ketteler, was murdered in the streets of Peking; and the official representatives of the powers were besieged in their legations at Peking. All the interested powers, including Japan and the United States, contributed troops to the force sent to remedy the situation. They relieved the legations and occupied Peking, and there was a renewed scramble for concessions by way of compensation. Germany was granted Kiaochow, Weihaiwei was leased to Britain.

DOWAGER EMPRESS OF CHINA. Tzu-Hsi (1835–1908), childless widow of the emperor Hien-feng, was the real ruler during the reign of her nephew Kwang Hsü from his accession, 1875, until her death.

Russo-Japanese War

In the new conditions thus created, the conflicting interests of Japan and Russia in Manchuria and Korea became critical. Japan invited compromise; Russia's idea of compromise was Japan's concession of all points in dispute. In 1902 Japan and Great Britain had made an open alliance binding each to come to the aid of the other in the event of attack by a combination of two or more powers, but not otherwise; therefore it was virtually certain that if Russia and Japan should go to war they would be left to fight out their duel.

In January 1904, Japan's final proposal that Russia should have a free hand in Manchuria and Japan in Korea was left unanswered; Japan declared war. Russia had enormously underrated both the efficiency and the numbers of the Japanese army, and still more Japan's advantages in a naval struggle. Huge as were Russian resources in men, there was but a single-line railway, not yet completed, to carry them across Siberia, whereas the Japanese were fighting close to their base. The Japanese fleet, commanded by Admiral Togo, outclassed and shattered the Russian, and in a series of engagements on land, more destructive and on a bigger scale than those even of the Franco-German War, the Japanese armies forced back the Russians under Kuropatkin. But the Japanese victory of Liao-yang was won only at a heavy cost in lives.

Port Arthur, the fortified seaport in Manchuria leased by Russia from China, was blockaded from the beginning of the war. It surrendered in January 1905, and a few weeks later Oyama attacked the Russian positions at Mukden, the capital of Manchuria. Though the Russians fought well, Kuropatkin was at length forced to order a retreat. Both sides had suffered tremendous losses, and in August a peace was negotiated at Portsmouth, U.S.A. Japan had become a world power.

JAPANESE AT LIAO-YANG. This photo shows Japanese infantry advancing during the nine-day battle of Liao-yang (Aug.–Sept. 1904) between the Japanese under Marshal Oyama and the Russian army commanded by Kuropatkin. The attackers suffered heavy losses but eventually triumphed owing to superior generalship. As a result of victory in the war, Japan took rank as one of the major world powers.

LESSON 24

The Americas, to the First World War

THE Civil War in the U.S.A. left the southern states in a deplorable condition—indeed, no great stretch of country had been so ravaged since the Thirty Years War had been fought across Germany. President Lincoln, with great wisdom, wanted to heal the country's dissensions as quickly as possible He advocated allowing the vote to any southerner who would swear allegiance to the United States, and the re-admission to the Union of any southern state in which 10 per cent. of the population thus enfranchised could set up a government. He wanted the Negroes to be freed and educated, without immediate enfranchisement. But he was assassinated before he could carry through his policy, and though his successor, Andrew Johnson, sought to follow Lincoln's lead he was not strong enough to sway Congress.

The South after the Civil War

Instead of conciliation, Congress adopted towards the South an attitude of vindictiveness that could not have been surpassed had the defeated foe been the most alien of enemies. Any southerner who, after taking an oath of allegiance to the constitution, had taken up arms against it was debarred from voting. This meant that, with few exceptions, the educated men of the South were ineligible to vote. The Negroes, on the other hand, were at once enfranchised by the Civil Rights Act of 1866, strengthened by the Fourteenth Amendment to the constitution, 1868, which declared all freedmen to be citizens of the United States with the same civil rights as white persons. The Negroes and the poor whites—equally untrained in political judgement—were the arbiters of the fate of the South through more than five years. Their votes were manipulated by a crowd of corrupt politicians from the North, popularly called "carpet-baggers" (from the fact that many of them arrived in the South with the minimum of luggage carried in a carpet bag), in ways that reflected little credit on them or the North. The conditions that arose from the abandonment of Lincoln's wise policy did more to perpetuate the hatred of the South for the North than all the disasters of the war itself. Not till the '70s did the North realize the state into which the political life of the South had fallen, and assist through the Amnesty Act of 1872 the re-emergence of the South's natural leaders. Complete amnesty was not granted till 1898, after the outbreak of war with Spain.

Emergence of the Negro Problem

As the South began to recover politically, the practical disfranchisement of the Negroes began. The Fifteenth Amendment, 1870, had decreed that no man might be debarred from voting on account of race, colour, or former condition of servitude ; but the southern states got round this broad ruling by introducing literacy and other qualifications for voting which excluded all save a few Negroes.

It was not very long, either, before the North realized that the abolition of slavery had revealed another problem : that of the Negro himself and his position in a country where, though his people were a minority, it was a large minority—in 1910 there were roughly 10 million Negroes in a population of 92 million (in 1950 there were 15,042,286 in a total population of 150,697,361).

MAKING RAILWAY HISTORY. Western settlement increased rapidly after the completion of the first transcontinental railway in 1869. This reproduction of an engraving in "Harper's Weekly" shows the meeting of the Union Pacific and Central Pacific at Promontory, Utah.

Railway Development

Up to the Civil War the United States was mainly an agricultural country. But necessities of war led to the development of industry on a considerable scale. Before the Civil War, customs duties were not much more than a revenue tariff. The Morrill and supplementary Acts raised them substantially during the war, and they were maintained at a high level after it, first to protect the Union's "infant industries" and afterwards as a part of America's policy of detachment. The Civil War also led to the laying down of many miles of railways for the transport of troops, munitions, and food, and these railways, when peace came, were rapidly pushed farther and farther afield until with the meeting at Promontory, Utah, in 1869 of the Union Pacific from Omaha and the Central Pacific from San Francisco it was possible to cross the continent by rail from the Pacific to the Atlantic coast. Other transcontinental lines followed.

Fate of American Indians

As the railways were pushed westward, the native Indians, like the herds of bison that had roamed for centuries over the great plains, were pushed westward too. The bison rapidly became extinct. The Indians were concentrated into reservations allotted to them by the government—which, however, after 1887, when the Indians had ceased to be a possible danger, adopted a new policy tending to their gradual absorption into the national life. The land thus cleared was devoted to cattle-raising, an industry that received a great impetus from the introduction in 1869 of refrigeration, which made it possible to send fresh meat from Chicago to New York, and ten years later from Chicago to London.

The Westward Movement

As the cattle-ranchers moved west, they were followed by agricultural settlers. The Homestead Act of 1862 offered 160 acres of land free to any citizen or prospective citizen who would settle on it and work it for five years. Tens of thousands of native-born citizens took up the land thus offered ; and thousands of immigrants—most of them Irish, German, or Swedish—came in from Europe. Between 1860 and 1880 over 65,000,000 acres were taken up, but so vast did the land seem, so limitless its power of absorbing new settlers, that no attempt was made to restrict immigration until the 20th century, except for the exclusion after 1882 of Chinese labourers, many of whom had come in to help construct the great railways.

The discovery of gold and silver in the far west encouraged western migration ; and the discovery of coal and iron close together in Alabama, and of petroleum in Texas and Oklahoma, led to the development of industry in the agricultural south.

While population was flowing westward, filling up the great plains, and adding more and more states to the original 13 of the eastern seaboard, the industrial towns of the east were growing rapidly ; and as the free land filled, immigrants from Europe began to settle in increasing numbers in the towns, where their presence created problems in administration and assimilation undreamt of in the days when newcomers-without-English were only scattered workers on the soil.

"Big Business" and Labour

The rapid industrial development of the United States, and the absence of all traditional restrictions, led to the concentration of immense power in the hands of "big business." Trusts—vast aggregations of capital — were formed which aimed at monopolising particular lines of business. The menace of these great corporations to the ordinary man and to the small business was early recognized ; the Interstate Commerce Act of 1887 and the Sherman Anti-Trust Act of 1890 endeavoured to put a brake on their activities. Theodore Roosevelt, president from 1901 to 1909, earned the title "trust-buster" through the energy with which he fought the trusts in the interests of social justice. A judgement of the United States Supreme Court in 1911 pronounced that the Standard Oil Company and the American Tobacco Company, two of the most powerful trusts in the country, were guilty of attempting to monopolise their commodities, and ordered them to disintegrate.

The growth of "big business" was accompanied by the formation of combinations of workers. The first, the Knights of Labor, founded in 1869, aimed at progressive reform in the political and economic fields. It was an unwieldy organization including all kinds of workers, skilled and unskilled, and it died out in the decade following 1886. In 1881 Samuel Gompers founded the American Federation of Labor which, with similar aims, was organized on more workable lines, and succeeded in getting some of the worst conditions of the labouring classes ameliorated. The Industrial Workers of the World, in theory a revolutionary body aiming at the destruction of the political state and of capital, in practice pursued much the same policy of amelioration. A threatened strike in 1916 by the powerful railway unions led the president, Woodrow Wilson, to force on Congress the Adamson Act, setting up a basic 8-hour day.

Isolation Ends

For a hundred years after the Declaration of Independence, the United States looked inwards to her own development. After the enunciation of the Monroe Doctrine, accepted by president after president as his own, the United States, fully occupied with her own growing pains, ignored European affairs. Moreover, this inclination to isolate herself was not affected by any attack on her from the outside.

But as the 19th century drew to an end she was forced to look over the wall. She did not at all like it when, in 1881, a French company presided over by Ferdinand de Lesseps, engineer responsible for the building of the Suez canal, began the construction of a canal across the isthmus of Panama, under a concession from Colombia. The company failed in 1889, in which year an American company began work on a rival canal through Nicaragua. In 1893 the American company failed ; and in 1894 a new French company was floated and continued work on the Panama scheme until 1899, when it also got into difficulties. By this time the war with Spain had brought forcibly home to the United States government the value, particularly in emergency, of such a canal in saving time on communication between the Pacific and Atlantic coasts. Congress set up the Isthmian Canal Commission, which bought out the French company. Work on the Panama canal was resumed in 1904, and the first steamer passed through it on August 3, 1914.

The Spanish-American War

War with Spain broke out in 1898. Feeling against Spain's tyrannous treatment of the people of Cuba had been running high for some time, and it came to a head as a result of the conviction of the American public that the blowing up of the United States warship *Maine* in Havana harbour was a hostile act on the part of Spain, and not an accident as the Spanish government asserted. The conflict lasted only four months, and remained a simple duel because of the certainty that any intervention by another power on behalf of Spain would bring the British fleet into play. The Americans were completely victorious, and annexed Porto Rico, Guam, and the Philippines. The United States had acquired Alaska by purchase from Russia in 1867, and a share in the Samoan Islands (with England and Germany) in 1889 ; and in 1898 she annexed the Hawaiian Islands.

The commercial treaty negotiated in 1854 governed American relations with Japan for many years. By 1907 the immigration of Japanese, particularly into California, was causing difficulties, and in a "gentleman's agreement," renewed in 1911, Japan pledged herself to issue no more passports to labourers. When the United States entered the First World War in 1917, she found herself the ally of Japan.

"Open Door" Policy in China

In 1899, when the European powers were scrambling for exclusive concessions in China, the United States declared for the "open door" policy, offering equal opportunities to all in the exploitation of China's trade and industrial possibilities. On November 2, 1917, she recognized Japan's "special interest in China."

Anglo-American relations were badly strained on more than one occasion during the second half of the 19th century. In 1861 two Southern envoys had been arrested by Federal agents while on board the British ship *Trent*. In response to British protests the Federal government apologised, and released the Southerners. In 1862, the *Alabama* and other Southern cruisers, built in England, had been allowed by the carelessness of the British government (which adopted an attitude of neutrality during the Civil War) to put to sea, where they almost destroyed the Federal merchant navy ; the resulting dispute was settled by arbitration in 1871.

British Guiana Dispute

A third cause of friction arose when in 1895 the United States tried to persuade Great Britain to agree to the settlement by arbitration of her dispute with Venezuela over the boundary between that country and British Guiana. After an exchange of sharp notes between Washington and London, Great Britain in the end agreed to arbitration—and secured most of the territory that had been in dispute. Great Britain's attitude during the Spanish-American War resulted in a great improvement in Anglo-American relations.

Successful Arbitration

The success the United States had had in persuading Great Britain to arbitrate gave U.S. statesmen hope for this method of settling international disputes, a method warmly urged by the American delegates at the Second Peace Conference at The Hague, 1907. In the next year the U.S. made 25 arbitration treaties with 25 different countries. In 1909 a long-standing dispute between Great Britain and the United States over the Newfoundland fisheries was referred to the Permanent Court of Arbitration at The Hague, and decided in 1910 in a way that satisfied both governments.

War in Europe

The outbreak of war in Europe in 1914 found the United States both totally unprepared for warlike activities on a large scale and determined to take no part in the conflict. United States neutrality was proclaimed and maintained for nearly three years, despite the disorganization of overseas trade caused by effective Allied blockade of neutral and belligerent Europe. The United States disliked the capture by the British navy of American vessels taking goods to European ports ; but she also disliked the acts of destruction committed in her factories and elsewhere by German agents trying to interfere with the flow of American munitions to the Allies.

The sinking on May 7, 1915, of the *Lusitania*, with the loss of 128 American lives, roused intense anti-German feeling in the country ; but President Wilson was still able to maintain his policy that a nation may be " too proud to fight." The German submarine campaign against mercantile vessels grew intenser and more ruthless, however, and this, coupled with the interception of a German dispatch promising to Mexico territories incorporated in the United States since 1848 if she would join in the war, led America to join the Allies, and to declare war on April 6, 1917.

Brazil Becomes a Republic

Bolívar aimed at creating a federation of all the states of Latin America, but he died too young to have a chance of achieving his aim and those who came after him did not share his vision. Instead, Latin America broke up into 20 countries. Portuguese-speaking Brazil, which contains at least half the area and half the population of the South American continent, was alone in enjoying something like stability of government from the beginning of her independence. Until 1889 Brazil was an empire. The deposition without bloodshed of Pedro II was followed by a military dictatorship and the establishment of a federal republic, the 20 provinces of the empire becoming autonomous states. The emperor's deposition was precipitated by the abolition of slavery in 1888, which caused the great landowners, thus deprived of an important part of their property, to join the republicans. The other countries of Latin America, republics from birth, went through long years of unrest and civil war, with periods of internal order during strong dictatorships.

Latin American Wars

Nor was the continent free from international conflicts. A bitter war raged during 1865–70 between Paraguay on the one side, Brazil, Argentina, and Uruguay on the other. Brought about by the aggressive ambition of Francisco Solano López, the Paraguayan dictator, it ended only with his death, by which time two-thirds of the population of Paraguay had been wiped out. In 1879 Chile went to war with Peru and Bolivia over the exploitation of the guano and nitrate deposits of the region.

Chile acquired from Bolivia her Pacific province of Antofagasta, 1884, from Peru the province of Tarapacá, and control of the provinces of Tacna and Arica, 1883.

Mexico and Porfirio Diaz

A period of civil war began in Mexico in 1855, and in 1861 Spanish, British, and French troops landed to enforce foreign rights. After the withdrawal of the British and Spanish in 1863 the French remained, and in 1864 installed Maximilian of Austria, younger brother of the emperor Francis Joseph and son-in-law of Leopold I of Belgium, as emperor of Mexico with the support of Napoleon III. For some years the new emperor maintained his position, but in 1866 the French troops were withdrawn and in 1867 Maximilian was taken prisoner and shot. After a short interval of anarchy, General Diaz seized the government and, except for the years 1881–84, ruled as autocratic president till 1910, when he was overthrown. His attempts to regain power failing, he resigned in 1911. Another period of turmoil followed.

PORFIRIO DIAZ (1830–1915), president of Mexico 1877–80 and 1884–1911 : his strong rule brought prosperity, but he was driven from power in 1910

South American Economic Development

In spite of civil disturbances and international wars the South American continent went ahead economically at an amazing rate. Europe wanted the many foods, metals, minerals, and raw materials that continent could produce ; and European, particularly British, capital was poured into Latin America to produce them. Railways were built, steam navigation was introduced and increased at sea and on the great rivers ; agricultural, pastoral, and mining industries were developed. Economic development and extended settlement made for increasing stability, and by the opening years of the 20th century political conditions in Latin America had steadied considerably.

Pan-American Union

The benevolent interest of the United States played a considerable part in the development of Latin-American stability. The United States was helping to carry on the ideas of Simon Bolívar, who called the first Pan-American Congress in 1826, when in 1890 it gathered together at Washington the first of a series of international conferences of American states.

That conference established the International Union of American republics, intended in the first place simply to collect and disseminate commercial information.

The fourth conference, held at Buenos Aires in 1910, changed the name of the permanent organization to the Pan-American Union, and the scope of its work was steadily enlarged to promote closer co-operation in all directions—intellectual, commercial, and political—among the American republics. One of its chief duties was to prepare the agenda for the Pan-American Conferences that, after 1890, met from time to time in the capitals of one or another of the countries belonging to it.

LESSON 25

The Drift to World War

SUNDRY events took place between 1895 and 1905 that had great significance for the future. In 1895 the world knew that some understanding—an entente—was established between Russia (where Nicholas II had not long succeeded Alexander III, and the old friction with Britain was lessening) and France, which was not at that time on the best of terms with either Britain or Italy.

The Fashoda incident troubled Anglo-French relations in 1898, and the South African War of 1899–1902 marked the isolation of Britain, but also surprised the world by showing the unexpected solidarity of the British Empire. In the early years of the century, the German emperor, William II, began greatly to expand the German navy—a development hard to separate from the idea of rivalry between Germany and Great Britain as the leading maritime power.

BULGARIAN TSAR. Ferdinand of Coburg, elected prince of Bulgaria in 1887, made himself tsar in 1908.

It was also significant, though in another direction, that the first Hague Conference was called in 1898 on the tsar's initiative, with a view to checking by international agreement the incubus of growing armaments, civilizing methods of warfare, and establishing an international court of arbitration. On all these matters some general and some partial agreements were reached. A Permanent Court of Arbitration was set up at The Hague; but reduction of armaments was virtually vetoed by the German refusal to participate.

"L'Entente Cordiale"

On the death of Queen Victoria and the accession of Edward VII in 1901, a far-reaching change was inaugurated. Diplomacy succeeded in reconciling the differences which had so long maintained friction between Great Britain on the one hand, and France and Russia on the other. In German eyes this entente—it was not an alliance—appeared to be precisely the consummation which Bismarck had successfully combated, intensifying the growing belief that the three powers were scheming for the destruction of the two Central empires. Germany and Austria therefore felt it necessary to make ready to meet, and it might be to anticipate, the attack of the three powers by the methods which had proved so successful under the guidance of Frederick the Great and of Bismarck.

But none of the three entente powers, least of all Britain, would have admitted at any time that there was any sort of justification for such apprehension, sedulously fostered in Austria and Germany until it took form as solid conviction even after Russia's failure in the Japanese war showed that Russian military power was far less effective than had been imagined. Friction arose between France and Germany concerning German interests in Morocco; it was dealt with by an international conference at Algeciras in 1906, where no one but Austria supported Germany's claims. Yet William II's government professed satisfaction with the outcome of the conference, while France's position in Morocco was confirmed and her proposed administrative reforms there were accepted by the sultan of Morocco.

Unrest in the Balkans

In 1908 the Balkans were once more in commotion, born of the rise of the "Young Turk" reforming party, which successfully imposed on the sultan its demand for a long-promised constitution. Ferdinand of Bulgaria seized the opportunity to assume full sovereign authority, with the old historic title of tsar, while Austria simultaneously announced annexation of Bosnia and Herzegovina, administered by her since the Congress of Berlin. Slavonic sentiment was alarmed and irritated; the action was, in effect, a challenge to Russia and Russia's influence and prestige among the Slavs, who, both within and without the Austrian empire, detested the Austro-Magyar domination. But Russia was warned in unmistakable terms that Austria could count on unqualified support from Germany, so that the tsar of Russia had no choice but to acquiesce. The Central Powers had recovered any prestige they might have lost at Algeciras.

The Young Turks, vehemently nationalist and anti-liberal in sentiment and encouraged by Germany, were masters of the Turkish government, and had substituted as sultan of Turkey and Khalif a feeble-minded brother for the crafty but unpopular Abdul Hamid II. Great Britain was rent by a constitutional struggle between the two houses of parliament and a revival of the Irish problem that had played a prominent part in British politics for nearly forty years. She was, moreover, entering on the anxious experiment of restoring full citizenship to her recent antagonists, the South African Boers, General Botha becoming the first premier of a united self-governing South Africa in 1910.

Agadir and Tripoli

It was easy to see in these facts the motive for what looked like an explicit threat to France when, in 1911, William II sent the gunboat *Panther* to Agadir to safeguard German interests in Morocco, on the plea that they were endangered by recent action on the part of France in that country. Great Britain made it clear that, in the event of conflict, she would support her informal ally, and the matter was adjusted.

Eleutherios VENIZELOS (1864–1936), Greek minister and virtual founder of the Balkan League of 1912.

Then came discord between the central empires and Italy, which entered on a somewhat desultory naval war with Turkey to extort from the Porte the cession of full sovereignty in Tripoli, where Italy had for some time past been seeking an equivalent for Tunis (annexed by the French). In October 1912 peace left Italy in possession of Tripoli and the captured Aegean islands.

The Balkan League

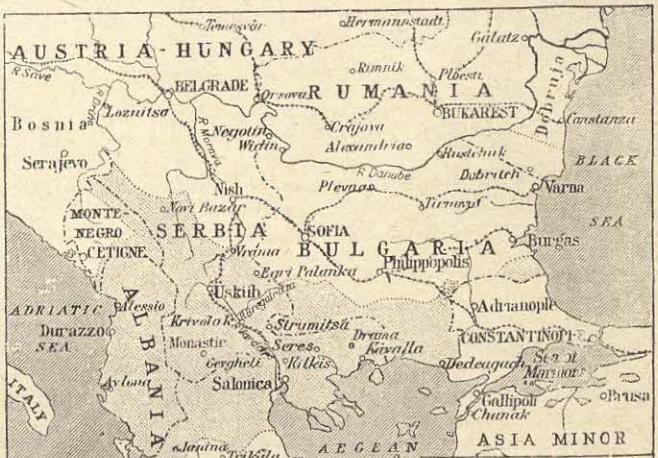
This war was the prologue to a fresh eruption in the Balkans. The Greek minister Venizelos had been secretly working for an unprecedented accord between the Balkan states which in 1912 issued in the formation of the Balkan League between Greece, Serbia, Bulgaria, and Montenegro, with liberation of Macedonia from Turkish rule as its primary object—very disturbing to the Great Powers, to whom it came as a surprise.

Albania rebelled against Turkish rule and won unexpected successes in Macedonia; the Balkan League appealed to the powers to intervene and, dissatisfied with their hesitation, declared war on its own account. The Turks were reorganizing their army under German tuition, but the process was incomplete, and the result was a Turkish *débâcle*. Bulgaria played the hardest and most successful part, capturing Adrianople and threatening Constantinople. Then the powers intervened and called the London Conference; under the treaty of London, May 1913, Bulgaria was to have acquired most of Thrace, and Turkey in Europe would have been reduced to Constantinople and a small area round it.

ENVER PASHA (1881–1922), leader of the "Young Turks" who overthrew Abdul Hamid II in 1909.

Second Balkan War

Bulgaria, considering that she had been robbed for the benefit of Serbia, almost immediately attacked that country. Greece promptly supported Serbia, and then Rumania joined them. Bulgaria was badly beaten. Only Serbia emerged from the two conflicts



AFTER THE SECOND BALKAN WAR. Fought in 1913 between the Bulgarians and the allied Serbians and Greeks, the second war followed the break-up of the Balkan League after the war of 1912. Bulgaria, who had been dissatisfied with her gains in the first war, lost part of them as the result of the second.

substantially strengthened. Now were revived in full measure the old vindictive jealousies among the Balkan states which Venizelos had succeeded for a short period in pacifying. In July 1913 Adrianople was recovered from the Bulgarians by Turkey. Nominally over the question of its surrender, the Young Turks, headed by Colonel Enver Bey, overthrew the cabinet by a *coup d'état* and set up a Young Turk government intent on the reconstruction of the Turkish empire.

PRELUDE TO TRAGEDY. Archduke Francis Ferdinand, heir to the throne of Austria-Hungary, with his wife at Sarajevo, the capital of Bosnia, a few minutes before both were shot. This murder precipitated the First World War.

Outbreak of First World War

Serbia blocked the way for Austrian expansion to the Aegean, and in Serbia was focused the Slavonic anti-Austrian feeling which was the most disintegrating force within that heterogeneous empire, for both Austria and Hungary included large Slav populations. Serbia, in Austria's belief, was a hotbed of Slav conspirators out of reach of the Austrian government. On June 28, 1914, the Austrian heir presumptive, Archduke Francis Ferdinand, and his wife, were assassinated in Sarajevo, the chief town of Bosnia, near the Serbian border, by a Serbian named Princip. Austria declared that the murder was a Serbian plot and that the Serbian government was responsible. Serbia denied this. But Austria presented an ultimatum to Serbia. Germany supported Austria's claims. Russia backed Serbia. Britain offered mediation, but Austria rejected all proposals of peaceful intervention and on July 28 declared war on Serbia. On the 31st both Austria and Russia were mobilising. On that day Germany sent an ultimatum to Russia and to France, who was bound by treaty to come to Russia's aid. On August 1, Germany declared war on Russia—and next day on France. So far it was reasonably debatable whether there was any moral obligation for Great Britain to come in ; but that was settled by Germany's invasion of Belgium, as an open road to France, on August 3, ignoring the treaty of 1839 guaranteeing Belgian neutrality ; and on August 4, after giving an ultimatum, Great Britain declared war on Germany.

LESSON 26

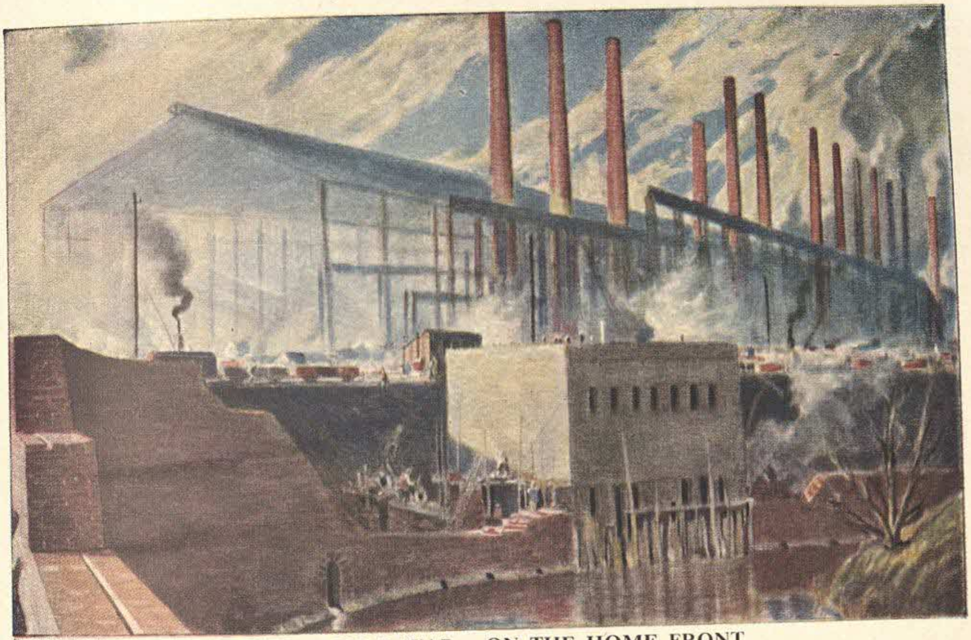
The First World War in Outline

On August 4, 1914, the two Central Powers, side by side and both under the single guidance of Berlin, had ranged against them on the east Russia with Serbia, and on the west France and Belgium, supported by Great Britain. The empires had their war-plan fully shaped, their armies ready for immediate action, a fleet powerful but much less so than that of Great Britain. They held the interior lines, so that they could mass their troops on either front at will, subject only to the efficiency of their roads and railways. They were much more powerfully armed than their adversaries, and Germany had not hesitated to violate the neutrality of Belgium (faithfully observed in the war of 1870–71), for the section of the French frontier which marches with that of Belgium, being nearly defenceless, could be swiftly penetrated by troops rushed through Belgian territory.

There was no reason for Germany to suppose that the Russian armies on the eastern front were more efficient than they had been ten years before, when Japan had so decisively defeated her, and Berlin took no account either of Belgium or of the few British regular troops that could be made available on the Continent immediately. Leaving Austria to hold any attack on the eastern front, the Germans, concentrating on the west, expected to smash their way through to Paris in a few weeks, to shatter France as a fighting force, and to deal at leisure afterwards with Great Britain and Russia.

Siege War in the West

This plan was foiled. The unexpected, stubborn, and heroic resistance of Belgium—the invasion of which prompted Great Britain's immediate entrance into the war—gave just time for a British force to take its place on the French left. The whole line was nowhere broken but was swung back, always covering Paris. Almost at the gates of Paris the first impetus of the German rush was exhausted. French reserves had been accumulating, and on September 6 the French opened a counter-attack. Then it was



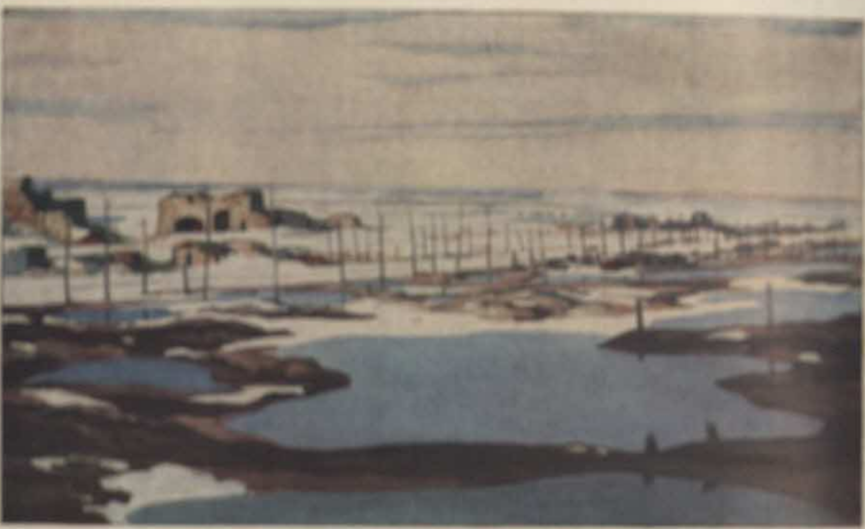
FIRST WORLD WAR: ON THE HOME FRONT

On an unprecedented scale the people at home in the United Kingdom laboured to support their armed forces. Factories were hurriedly built to supply sorely needed munitions of war. This reproduction of a painting by Sir Charles Holmes shows the Phoenix steel works erected in Sheffield, specially for war production, in 1916.

TRENCH WARFARE IN FRANCE

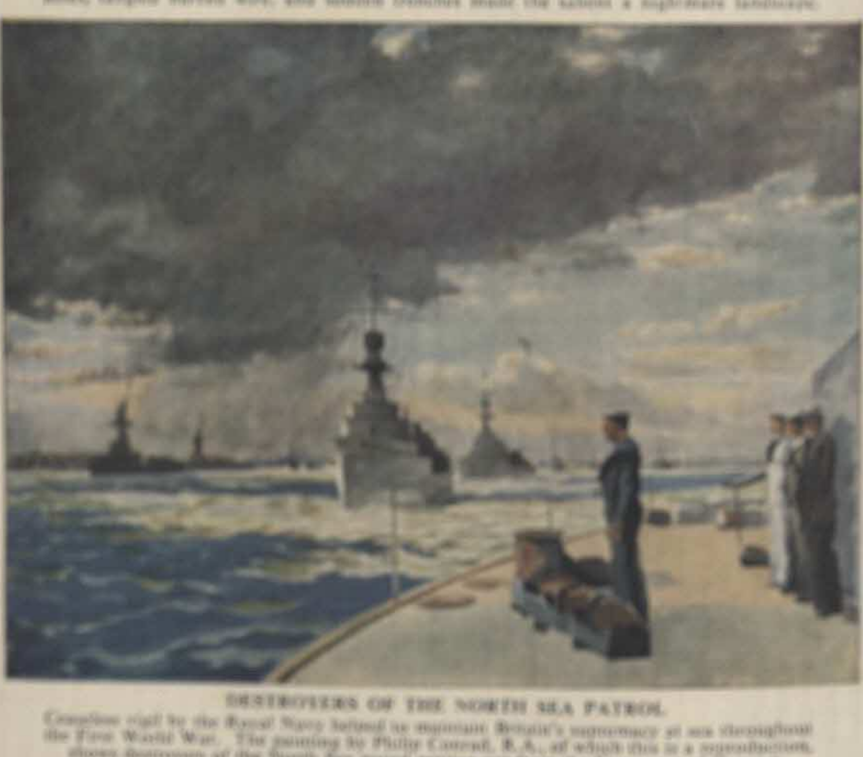
Here is an impression by John Nash, R.A., of the 1st Artists' Rifles going " over the top " at Marcoing, near Cambrai, on December 30, 1917.

Crown copyright, Imperial War Museum



THE DESOLATION THAT WAS YPRES

For long periods in 1914-18 the opposing armies on the Continent were bogged down by mud. This reproduction of a painting by Sir David Y. Cameron, R.A., shows a winter scene in the Ypres salient, *Flanders*. Shattered villages and farms, blasted trees, water-filled shell-holes, tangled barbed wire, and sodden trenches made the salient a nightmare landscape.



DESTROYERS OF THE NORTH SEA PATROL

Ceaseless vigil by the Royal Navy helped to maintain Britain's supremacy at sea throughout the First World War. The painting by Philip Connard, R.A., of which this is a reproduction, shows destroyers of the North Sea patrol putting out from the Essex port of Harwich.

Crown copyright, Imperial War Museum

FRENCH COMMANDERS. Marshal Joseph Jacques Césaire Joffre, 1852–1931 (centre), led the French armies 1914–16. Henri Philippe Pétain, 1856–1951 (right), held Verdun, and in 1918 became C.-in-C. under Ferdinand Foch, 1851–1929 (left), Allied generalissimo from March 1918.

the German line that swung back, the battle of the Marne, September 6–10, developing into the battle of the Aisne, September 12–28, each line striving and failing to turn the other's western flank till both stretched up to the Belgian coast at Nieuport and Ostend respectively. By about the middle of October 1914 both lines were stabilised. The war on the western front took shape as a seemingly interminable siege, a ceaseless battle for the capturing and re-capturing of a trench here and a trench there in the hope of forcing a penetration that would effectively break the enemy's line.

The Eastern Front

Japan's accession to the Allies (under the Anglo-Japanese treaty of alliance of 1902) in the first month of the war helped to clear the seas of German raiders, and Japanese fleets convoyed Indian and Australian troops to the west. Turkey joined the Central Powers at the moment when the western front was stabilised, providing a new source of anxiety for both Russia and Britain. Russia attacked with unexpected vigour in East Prussia, with forces disastrously shattered, after initial success, in the battle of Tannenberg. In spite of this defeat, Russia moved a second army on Galicia. Germany, obliged to go to the help of Austria, made several hurried advances into Russian Poland, followed by successive evacuations, always failing to bring the Russians to a decisive engagement and compelled to fall back because her forces were too far from their base.

Poison Gas Used

Thus for more than a year the adversaries stood in the west, hammering, attacking, counter-attacking, each occasionally gaining a mile or two of ground, but neither able to make any substantial advance, still less to penetrate the opposing line; while in the east they swung backwards and forwards over a vast territory.

On the western front, after six months of war, it was realised that infantry alone was powerless in trench warfare, and in 1915 a great artillery duel began. At Neuve Chapelle in March and at Loos in September, intense gunfire preparation preceded British attacks. At the second battle of Ypres, in April 1915, the Germans used poison gas, repudiated as a permissible instrument of war by The Hague Convention of 1907. Advance by either side in the west remained negligible.

But there were other developments in 1915. Italy entered the war on the side of the Allies. The entente was sympathetic to Italy's historic claims on the east of the Adriatic, and on May 23 she declared war on Austria. British and Russian campaigns against the Turks included the imaginative but unsuccessful British attempt to take the Central Powers in the rear, and establish contact with Russia, by capturing the Dardanelles. Germany began her submarine war and the torpedoing of non-combatant ships, signalised by the sinking of the passenger liner *Lusitania* on May 7, 1915. Great Britain retorted by declaring a general blockade of the Continent. The British failure in the Dardanelles encouraged Bulgaria to join the Central Powers in October and, with Austria, to fall upon Serbia, while with the assent of one half of Greece an Allied force occupied Salonica (Thessaloniki).

Verdun

In 1916 a tremendous German attack was hurled upon the French at Verdun. The commander of Verdun, General Pétain, said "Ils ne passeront pas" (they shall not pass), and he kept his word. Four times in four months onslaught after onslaught drove in the French line at the cost of severe losses to both armies; but Verdun was held. This German offensive, a climax of the land fighting in the west,

GERMAN WAR LEADERS. Left, William II (1859–1941), German emperor 1888–1918. Centre, Field-Marshal Paul von Hindenburg (1847–1934), Chief of the general staff from 1916. Right, Field-Marshal Erich von Ludendorff (1865–1937), victor of Tannenberg, 1914.

IN THE ANCRE VALLEY. The last stage in the First Battle of the Somme was the successful British attack along the Ancre, a northern tributary of the Somme, in November 1916. Troops are seen here tramping through the mud of the Ancre valley.

forestalled a great Allied " push " designed for the summer of 1916. In order to relieve the French, the Allied attack was started on July 1 before preparations were complete. This attack, stretched out along an extended line, was the first battle of the Somme. A heavy artillery bombardment lasting for several days preceded it. Some ground was gained, but not enough to have a practical effect on the general situation.

In May 1916 the battle of Jutland, great naval engagement of the war, was fought (*see* BRITISH HISTORY). The German fleet came out and engaged a portion of the British fleet, but on the approach of the main fleet escaped skilfully to the cover of its mines and, except for its submarines, never ventured out again.

While the Verdun struggle was in progress Austria struck at Italy in Trentino, but found the adventure too much for her—the more so because the Russians developed a new offensive in Galicia ; this in turn encouraged Rumania, hitherto neutral, to take the field against Austria. The result was disastrous to Rumania: the Germans came to the rescue of their ally, drove the Rumanians back, and invaded Rumania, taking Bukarest, the capital, on December 5, 1916.

United States Enters the War

In the new year, 1917, the Allies in the west continued to advance slowly ; the battle of June 7 for the Messines ridge was followed by the last of the great Allied artillery offensives on the western front, the third battle of Ypres, July 31. During the spring two developments of the highest importance had taken place : the United States of America's declaration of war on the Central Powers in April, which made it imperative for the Germans, if they were to achieve victory, to do so before the Americans could take the field in force ; and the Russian Revolution in March, which paralysed Russia as a force in the war and led before the end of the year to the switching to the west of German troops no longer needed on the eastern front. At the beginning of November (the end of October by the Julian calendar) came the second Russian Revolution in which the Communist party seized power ; in March 1918 the new government, headed by Lenin and Trotsky, negotiated the treaty of Brest-Litovsk with the Central Powers, and withdrew Russia from the war.

The Italian army, pressing on the Austrian front, was routed at Caporetto in October 1917 and driven back in headlong retreat till it was able to make a stand on the Piave.

In January 1918 preparations began for the decisive struggle in the west. In March, Foch was appointed Allied commander in France ; the arrival of the United States troops was imminent. On the morning of March 21, 1918, began the battle of St. Quentin, sometimes called the second battle of the Somme. The Germans hurled themselves at the centre of the Allied line on the Somme, and for a week the British were swept back. But the line was not broken, and the British were at last able to turn and repulse the enemy. A renewed attack on the British left in April was held.

Beginning of the End

United States troops were already in France when the Germans, under the command of Ludendorff, staked all on a final throw, a thrust against the French left which began on May 27 and lasted throughout June. Then on July 18 the initiative passed to Foch, who opened what proved to be the victory offensive. Sector by sector the German line was pushed back till by the middle of September it stood again where it had stood at the beginning of Ludendorff's spring offensive.

The last stage opened before the middle of September. The Germans were driven by the British out of the " Hindenburg line," strong defensive works they had constructed east of Arras ; by the Americans out of St. Mihiel. On other fronts their allies were failing : Bulgaria capitulated ; the Turks were being defeated everywhere ; Austria, worn out, asked for an armistice on November 3. Germany, now alone, fought on stubbornly ; but demoralisation was spreading among the troops as well as among the civilian population, broken by the British blockade. On October 26 Ludendorff resigned ; a week later the Americans accelerated their push down the Meuse ; the French were pressing hard on the centre ; on the left the British captured Valenciennes, and on November 9 they were over the Escaut (Scheldt). Mutiny broke out in the German fleet at Kiel, and revolution in Berlin. The German emperor fled to the neutral Netherlands. A provisional Socialist government was set up in Germany whose delegates on November 11, 1918, signed, in the forest of Compiègne, the dictated armistice that ended the fighting in the First World War.

LESSON 27

Between the Wars: Uneasy Peace in Europe

THE Great Powers and the smaller assembled at Versailles, to draw up the treaties intended to start a war-weary Europe on a new era of perpetual peace. Something of the spirit of the Fourteen Points promulgated from Washington by President Wilson in January 1918 found its way into the results of the deliberations, though several of his recommendations—for instance, the removal of economic barriers, and the giving of all possible assistance to Russia in the working out of her own way of living—were not incorporated. But Wilson did persuade the European delegates to accept his idea of a general association of nations, and provisions for the formation of the League of Nations were included in the main treaty, the treaty of Versailles, which came into effect in January 1920.

The general acceptance of the League idea, and with it the recognition by governments of a moral obligation to regulate their activities by the rules of universal justice, certainly led the peoples to regard the state of the world more hopefully than was in the event justified. For already in 1919 the newly constituted republic of Poland committed acts of aggression, occupying Galicia, wresting Vilna from Lithuania, and invading the Ukraine where her troops were held only at Kiev by the Red Army. Driven back on Warsaw, the Poles, led by the French General Weygand, once more pushed back the Russians.

In the peace signed at Riga in 1921 Poland secured an area of White Russia inhabited by some four million Russians.

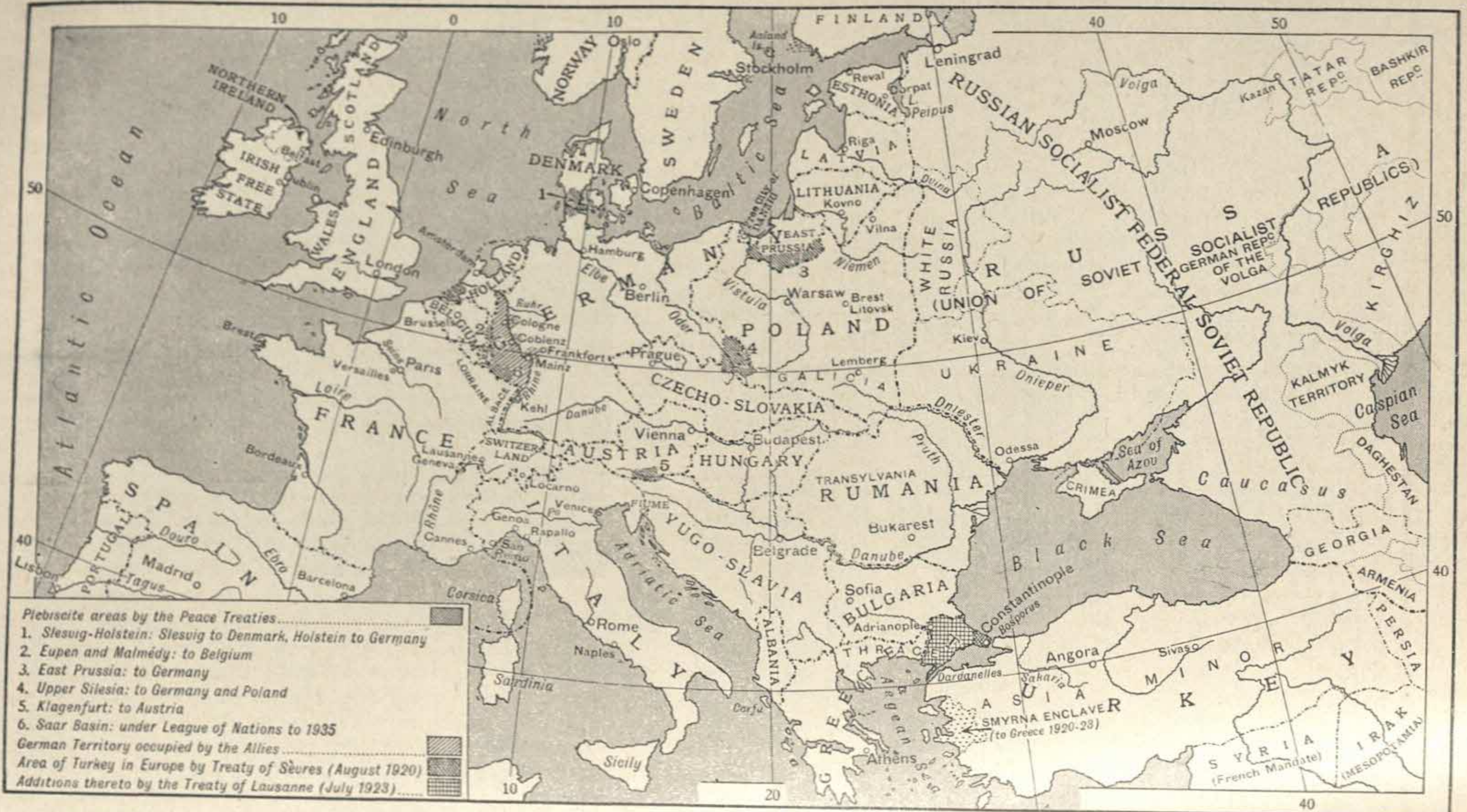
New States Formed

Poland was but one of the new states created by the war. The old Austro-Hungarian empire, for whose peoples Wilson had proposed autonomy, was split up : Hungary, half its former size, received its independence ; an entirely new state, the republic of Czechoslovakia, was constituted out of the old kingdom of Bohemia, with the addition of Slovakia, Moravia, and Carpathian Ruthenia. The Baltic states, Finland, Estonia, Latvia, and Lithuania, broke away from Russia, which recognized their independence in 1920. In 1914 there were 20 states in Europe, 11 of them small. In 1920 there were 27, 16 of them small, and 5 of only moderate size.

Reparations and War Debts

The treaties signed, and the new states constituted, the Allies attempted to settle the double question of reparations and war debts, for the Allies were heavily indebted to one another. Only the United States was solely a creditor, and she had lent to all her allies. France's representative, Clemenceau, was firmly of the

THE "BIG FOUR." Representatives of Britain, Italy, France, and the United States at Versailles ; they are (left to right) Lloyd George, Orlando, Clemenceau, and Woodrow Wilson. They negotiated with Germany the Treaty of Versailles, signed June 28, 1919, which created the League of Nations.



EUROPE AS REARRANGED AFTER THE FIRST WORLD WAR. Whereas after Waterloo the policy on which the redistribution of Europe was effected was governed by dynastic considerations, the basic principle of its redistribution by the Treaty of Versailles in 1919 was the satisfaction of national aspirations and recognition of the right to self-determination of all nations. In this map the main divisions of the new Europe are shown with shaded portions indicating areas where the ultimate settlement was left to popular plebiscite ; also the areas inside German territory occupied by the victorious Allies pending fulfilment by the Central powers of the obligations imposed upon them by the peace treaties.

opinion that reparations from Germany could and should cover both all war damage and all France's indebtedness, and was ready to go to all lengths to force Germany to pay. The Spa agreement of July 1920 settled the proportions of reparations the Allies were to get : France was to receive 52 per cent., Belgium 8 per cent., the British Empire 22 per cent. The remaining 18 per cent. was divided among Japan and the other allies. The original claim of the Allies against Germany amounted to £11,300,000,000; but early in 1921 this was reduced to £6,600,000,000, to be paid in annuities of £100,000,000 plus 26 per cent. of Germany's exports. The first payment of £50,000,000 was actually made on September 1, 1921, and deliveries in kind (chief of which was coal) covered the period up to November 1921.

Inflation in Germany

But in December the German government notified the Reparations Commission that as they had been unable to raise a loan they could, in addition to deliveries in kind, pay only £10,000,000 on account of the sums due in January and February 1922. A moratorium was granted, and a little later France agreed to consider the reduction of Germany's total indebtedness if her own debts were remitted. But negotiations seemed to make little headway, and in 1923 French and Belgian troops marched into the Ruhr in an effort to force payment from Germany, whose reply was a passive resistance that ruined her finance and her currency : 20·5 marks bought £1 in 1914 ; in June 1920 it took 200 marks, in October 1922 about 22,000 ; in January about 49,000 — a startling enough rise — and by November the value of the pound had reached the astronomical figure of 20,500,000,000,000 marks. The total payments exacted from the Ruhr were less than a third of the minimum payment expected under the arrangement in force when France marched in.

Dawes and Young Plans

The outlook for collecting reparations was poor, and towards the end of 1923 an international committee of experts was appointed under the chairmanship of General Dawes of the United States. Its purpose was the dual one of securing recovery of the debt Germany owed, and making it possible for her to pay by helping her to stabilise her currency and balance her budget. The success of the Dawes plan rested on the raising by Germany of an external loan of £40,000,000 sterling—much of which was subscribed by the United States. Payments were to begin at 1,000 million gold marks (£50,000,000) a year, and work up to 2,500 million gold marks (£125,000,000) a year, and were secured on taxes, the railways, and industrial debentures. The plan was favourably received, and was accepted by Germany. France evacuated the Ruhr in July 1925, and in the improved international atmosphere Germany was admitted to the League of Nations in 1926. In 1929 the Dawes plan was succeeded by the Young plan, which reduced the annuities payable, limited the number of yearly payments to 59, and created the Bank for International Settlements at Basle to handle all reparations transactions.

Hoover Moratorium

Two years later the world slump, originating in the 1929 depression in the United States, hit Europe. Neither Germany nor the Allies could continue the payment of their war debts, and the Hoover moratorium—intended as a temporary measure—released enemy and ally alike from the immediate nightmare of unpaid debt.

The withdrawal in 1920 of the United States from participation in the deliberations of the Council which had been attempting to settle European affairs after the signing of the treaties left Great Britain and France in control, and the difficulties of both political settlement and international debt collecting were much exacerbated by the fundamental difference between the French and the British attitude. Great Britain's aim was reconciliation, and a prosperous and united Germany. France wanted Germany weakened. Under the treaties, pieces of pre-1914 Germany had been detached—Alsace-Lorraine to France, cantons taken from the South Netherlands in 1815 to Belgium, Danish Schleswig to Denmark, German Poland to Poland ; and Danzig, 96 per cent. German, had, though claimed by Poland, been established as a free city under the protection of the League of Nations.

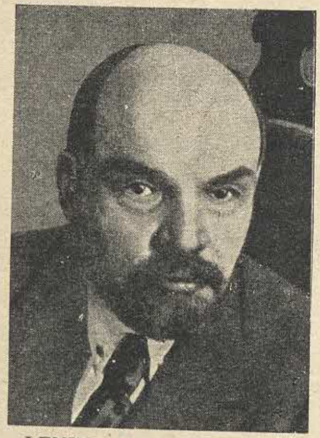
Separatism in the Rhineland

The treaty of Versailles laid down that the left bank of the Rhine was to be demilitarised for ever when Allied occupation of the area ended (under that treaty, in 1935). France favoured an indefinite occupation of the area by the Allies ; the other Allies agreed that they should evacuate the left bank in three zones—the north after five years, the centre after ten, and the south after fifteen, if the Germans carried out in full their obligations to disarm and pay reparations. There was a strong desire in the Roman Catholic Rhineland for separation from Prussia, and after France occupied the Ruhr in 1923 she aided this separatist movement. An armed rising took place in the autumn of 1923. At Düsseldorf it was quickly suppressed. The Rhineland republic, proclaimed at Aachen, lasted only from October 21 to November 2, 1923. Opposition in Coblenz, Wiesbaden, and Mainz came to an end in January 1924 ; but civil war went on in the

Palatinate till May, when the separatist movement died down.

The Succession States

The break-up of the Austro-Hungarian empire into a number of states completely upset the commercial life of that interdependent area, for the new nations at once set up customs barriers against former hated fellow-subjects, who had now become hated neighbours. Austria in particular was in a parlous state. Vienna, formerly the splendid seat of government of an empire of 240,000 square miles, was now the overgrown capital of a state about one-sixth that size, and contained nearly 30 per cent. of its population. Suggestions for the formation of a customs union among the succession states were as unwelcome to the Allies as to the states themselves; and any kind of union, customs or political, between Germany and Austria was expressly forbidden by the peace treaties.



LENIN. Name adopted by Vladimir Ilyich Ulianov. The October revolution, 1917, made him dictator of Russia.

Czechoslovakia, a completely new creation, proved to be the most enlightened of the succession states. Beneš, her far-seeing foreign minister, succeeded in forming what came to be known as the Little Entente between his own country, the kingdom of the Serbs, Croats, and Slovenes (the new and enlarged Serbia, renamed Yugoslavia in 1931), and Rumania. The Little Entente was aimed chiefly at defence against possible aggression by Hungary, which was anxious to recover areas assigned by the peace treaties to Rumania and Czechoslovakia; but it found expression also in commercial treaties between its members, and later between them and their neighbours. Czechoslovakia was also the first country in Europe to start trading with Soviet Russia. She entered into an agreement with Austria (December 1921) binding each state to abandon propaganda hostile to the other, and to settle disputes by arbitration—a method of international action of which Beneš was an ardent supporter.

Civil War in Russia

After concluding the treaty of Brest-Litovsk in March 1918, Russia had ceased to participate in the war against Germany; but she had not seen the end of fighting on her soil. For several years White (anti-Soviet) generals carried on a campaign with Allied assistance. Czech deserters from the Austrian armies numbering 45,000 or more, who had been formed into an army to fight for the liberation of their country alongside the Russians, were, after Russia's collapse, transported across Siberia to be sent to the western front. They attacked the Soviet forces in Siberia, ousting the Vladivostock soviet and setting up a new government there with the approval of the Allies. By July 1918, when the tsar was executed, almost the whole of Siberia was in the hands of White forces, and the Czechs were moving westward again towards Russia-in-Europe.

British forces landed at Murmansk in August, and by the end of the year there were 15,000 British and American troops in north Russia, 7,000 Americans were guarding the Trans-Siberian and Chinese Eastern Railways, 7,000 British were supporting Admiral Kolchak's White All-Russian government in Siberia, 70,000 Japanese were holding important strategic points in the east of that vast country; and the French had occupied Odessa. General Denikin in south-west Russia, and General Yudenich in Estonia, also received ample supplies from the Allies. But the Czechs decided to abandon the campaign, and the White armies collapsed, chiefly because of the hostility of the people in the areas over which they had gained control and without whose help the troops could not be maintained in the field.

Famine and Pestilence

In 1921 the harvest of grain sown in the previous autumn failed, and the spring-sown grain failed likewise, owing to drought. Russia was stricken by famine, and cholera and typhus followed. An appeal was sent to Mr. Herbert Hoover, who was in charge of the American relief administration helping to restore normal life in the European countries that had suffered most from the British blockade during the war. By March 1922 the Hoover organization was feeding daily 10 million Russian children and adults. Relief from abroad probably fed altogether 12 million, and the Soviet government assisted as many again; but this period of famine and disease put back by years Russia's recovery from war, revolution, and civil war.

In its opening phase the Russian revolution admitted of no adulteration of the Communist principles on which it was founded, and the establishment of the Third (Communist) International (the Comintern) at Moscow in March 1919, whose aim was to carry revolution to the rest of the world, was a great handicap to the re-establishment of normal relations between Soviet Russia and other countries. Ostensibly an independent organization, the Comintern appeared to outsiders to be merely an instrument of Soviet policy. Lenin himself, however, departed from the pure doctrine of Communism when, under pressure of circumstances, he introduced his New Economic Policy in 1921 : this permitted freedom of trading within Russia, overtime and piece work payment for workers, encouraged the investment of foreign capital by offering concessions, and by implication recognized rights of private property which had been abolished in the militant opening phase of the revolution. The Russian Soviet Federal Socialist Republic, White Russia, the Ukraine, and Transcaucasia formed themselves into the Union of Soviet Socialist Republics (U.S.S.R.) in 1923 ; other areas, including republics established in central Asia, were subsequently admitted to the Union.

Russia Re-enters World Affairs

Soviet Russia was invited to participate at an international conference for the first time when her envoys attended the Genoa conference in 1922. While the other powers were trying to overcome the objections of France (whose prime minister had changed since the invitation was issued) to Russia's presence, Russia and Germany, both " bad boys " and outsiders at the conference, got together and signed an agreement at Rapallo shelving the question of debts, affirming mutual friendship, and re-establishing full diplomatic relations. This agreement alarmed the rest of the representatives at Genoa, and the conference proved otherwise abortive. But it marked the beginning of Russia's re-entry into the life of the outside world.

Soviet trading corporations were established in London, Berlin, New York, and elsewhere, and though French and American business men hesitated to give Russia long term credits those of England and Germany took the risk, and when Lenin died in January 1924 Soviet Russia's economic position had much improved : her exports, worth only 20 million pre-war gold roubles in 1921, increased to 369 million in 1923–24. Her internal trade and productiveness improved correspondingly ; and in 1928 she was able to embark on her first Five Year Plan, which set as a goal a degree of industrial development that to western Europe seemed impossible of attainment in the time allotted.

Great Britain recognized the Soviet as the *de jure* government of Russia in February 1924, and a year later all the great powers, except the United States and Latin America, were in diplomatic relations with her. But she was refused admission to the League of Nations in 1926 ; and in 1927 Anglo-Russian diplomatic relations were severed. The U.S.S.R., whose government supported disarmament, took part in the abortive disarmament conferences held at Geneva in 1927 and 1928 ; her representative, Maxim Litvinov, coined the striking phrase, " Peace is indivisible." Russia was excluded from the original signatories (15 in number, and including the United States and Germany) of the pact of non-aggression which Mr. Kellogg of the United States was instrumental in arranging in 1928 ; but she signed it later.

Fascism in Italy

A revolution of a different kind took place in Italy in 1922, when the followers of the renegade Socialist Mussolini, after Labour and Communist disturbances in the industrial areas, marched into Rome (Mussolini followed by train 24 hours later). Organized by him into " fasci " (bundles) and taking as their emblem the fasces of the lictors of ancient Rome, with the king's connivance they occupied the city peacefully, and Mussolini accepted the king's invitation to form a government. The basis of Fascism was the theory that the state does not exist for the citizen but the citizen for the state, and Mussolini set about suppressing all opposition and making Italy a one-party —the Fascist party —state.

IL DUCE. Benito Mussolini, Fascist chief, giving the Fascist salute. Dictator of Italy 1922–43, he was called " il duce " (the leader).

Influential opponents were murdered, driven into exile, or imprisoned, and within a few years he had achieved his aim, aided by the popular appeal of his generally bold manner in international affairs, and such actions as his conclusion in 1924 of an agreement with Yugoslavia recognising Fiume as Italian. The Versailles treaties had made Fiume, claimed by both Italy and Yugoslavia, autonomous, but since the Italian poet D'Annunzio occupied it in a private raid in 1919 it had in fact been Italian. This fact Mussolini, ignoring the Versailles decision, got Yugoslavia to recognize. Another measure that helped his popularity in Italy was the treaty of 1929 with the Vatican, which restored the Papacy as a sovereign state by allotting to it the city of the Vatican.

LESSON 28

Undeclared War

THE American slump of 1929 had very serious effects on Europe. It put a stop to the enormous sums of American capital which had been pouring into Germany, and this completely upset the very precarious conditions of international trade and confidence. Mass unemployment in America was followed by mass unemployment in all the highly industrialised countries of Europe, with unfortunate political and economic results both internally and internationally.

Rise of the Nazi Party

The most momentous result was the emergence into power in Germany of Adolf Hitler and his National Socialist Party. In 1923, at the time of the separatist risings in the Rhineland, Hitler had attempted unsuccessfully to seize power in Munich. He was arrested and sentenced to five years' imprisonment, of which he served only eight months. The German Workers' Party, for which Hitler was at that time propagandist, secured 32 seats in the election of May 1924, but dropped to 14 in the December election of the same year. Hitler's gift of oratory made him before long the leader of his party, whose title he changed in 1925 to National Socialist German Workers' Party. It got only 12 seats in the elections of 1928: but in 1930 the National Socialists, or Nazi party as they were now called, secured the second largest number of seats in the Reichstag—107 out of a total of 475 seats, the Social Democrats having 143.

LEADERS AND LED. President Hindenburg is here sitting between Hitler and Goering at the Tannenberg commemoration in 1933. Hitler had become Reich chancellor, and Goering was Prussian premier. Hindenburg, elected German president 1925, was re-elected 1932, when his chief rival was Hitler.

By August 1932 Hitler felt strong enough to demand the chancellorship of the Reich and the premiership of Prussia.

Hitler as Chancellor

President Hindenburg offered him the vice-chancellorship, and the Prussian premiership, which he refused; but Hindenburg gave way to pressure, and on January 30, 1933, appointed him chancellor. A month later the Reichstag building was opportunely fired, and asserting, without evidence, that "serious suspicion" rested on the Communist members, Hitler had them arrested. He also started immediately to suppress the Jews, expelling all Jewish judges and lawyers from the courts and all Jewish professors from the universities. He insisted constantly that the Jews and the Communists, whose associations were international rather than national, were responsible for the state of Germany; and before many weeks had gone by the Roman Catholic Church—again because of its international character—was added to the scapegoats.

The successful challenge of the Nazis in Germany to established government gave an impetus to analogous movements elsewhere. Greiser, with the active assistance of German police and Nazi storm troopers from across the frontier, gained control of the free city of Danzig in May 1933. In Austria, the Nazis early in 1934 demanded union with Germany, and tried to put their demand into effect by force. Their attempt produced a joint declaration from France, Great Britain, and Italy that they regarded the maintenance of Austria's independence as essential—renewed efforts by the Austrian government to bring about a customs union had already been vetoed by the powers in 1931. The Austrian chancellor Dollfuss, who, to secure support from Mussolini, fought and destroyed the Austrian Socialist party, also refused to give way to the German Nazis, and was assassinated. Dr. Schuschnigg, one of Dollfuss's ministers, succeeded him as chancellor, and, backed by Mussolini, managed to curb the Austrian Nazis.

Italian Conquest of Abyssinia

In May 1935 France and the U.S.S.R. (which had been admitted to the League of Nations in September 1934) signed a pact of mutual assistance—an event which resulted in a drawing together of the German and Italian dictators. This bond was strengthened when, in October 1935, Mussolini, taking advantage of a dispute over an alleged shooting affray near the undefined Abyssinia-Italian Somaliland frontier, defied the League of Nations and invaded Abyssinia. Using bombs and gas from the air, tanks and modern arms on the ground, against the poorly equipped Abyssinians, the Italian forces conquered the country in eight months. The emperor Haile Selassie fled : he had appealed in vain for the protection of the League of Nations — to membership of which Abyssinia had at Italy's suggestion been admitted in 1923 ; and Mussolini on May 9 announced the annexation of Abyssinia, declaring King Victor Emmanuel III to be its emperor, with Marshal Badoglio, the leader of the successful campaign, as viceroy and governor-general. The League had, indeed, agreed that its members should enforce sanctions against Italy, but those nations (including Great Britain) which acted on this agreement did so in a half-hearted way, and abandoned them once the conquest was an accomplished fact.

SPAIN'S DICTATOR. General Franco (b. 1892), leader of the Falangist revolt against the government in 1936, installed himself as " Head of the Spanish State and Government " in 1939.

In March 1936 Hitler occupied the Rhineland (which had been evacuated by the Allies in 1930), although by the treaty of Versailles it had been demilitarised for ever; he stated that he did this as a rejoinder to the Franco-Russian pact.

Civil War in Spain

Taking advantage of the ineptitude and corruption of Spanish politics, Primo de Rivera had rebelled in 1923, and with King Alfonso's support set up a military dictatorship in emulation of the Fascist dictatorship in Italy. De Rivera's government lasted till 1930, when, having lost the confidence of the army, he resigned and retired to Paris, where he died two months later. He was succeeded by General Berenguer. A republican revolution broke out in 1931 which swept Alfonso from the throne, and the military dictatorship from power.

But Spain still lacked stable government. Riots, strikes, and rebellions tore the land, complicated by demands for home rule from the Basques and the Catalans. At last, in 1936, a "Popular Front" was formed by Socialists, Communists, Anarchists, and advanced Liberals, who between them secured 272 seats — 162 Liberal, 94 Socialist, and 16 Communist—out of 470 in the February elections. But in July, before the newly elected government had had time to show how far it could control the country, it was faced by a military revolt from the extreme right : General Franco led a rising of the Foreign Legion in Morocco, which was followed by garrison revolts in Spain itself.

Half the fleet and most of the air force remained loyal to the government, but the bulk of the army joined the insurgents. Italian bombers drove government warships from the Strait of Gibraltar, enabling Franco to cross to the mainland, where his forces stormed Badajoz, and occupied Irun and San Sebastian. A convergent attack on Madrid followed. A remark made at this time, that four columns were advancing on Madrid, and a fifth—friends in Madrid itself—was helping Franco to victory, is the origin of the expression " fifth columnist " as a synonym for traitor. Italian and German aircraft began to bomb Madrid on October 3, and on November 7 the government left Madrid for Valencia. The International Brigade, a group of volunteers eventually running into thousands, and from many lands, took service with the government, and Russia sent some aeroplanes to its aid.

All this time Great Britain, fearful of repercussions in the rest of Europe, had been urging, and acting on, a policy of non-intervention—which in practice meant that the legal Spanish government was unable to secure arms and supplies while Germany and Italy, though parties to the non-intervention pact, were

THE MEN OF MUNICH. On Sept. 29, 1938, immediate war was averted by the dismemberment of Czechoslovakia. This picture shows the four chief figures at the conference: Neville Chamberlain, British Prime Minister; Daladier, French Premier; Hitler, Germany's Führer; and Mussolini, Italy's Duce.

supplying the rebels with arms, aeroplanes, and men. The unequal struggle dragged on with ferocity and varying success until in March 1939 General Franco captured Barcelona and Madrid, the government's last strongholds, and established himself as dictator, after the model of Hitler and Mussolini, through whose help he had defeated his fellow-countrymen: Italy admitted to sending 40,000 men to aid Franco.

"Guns Before Butter"

In 1935 Hitler announced the re-introduction of conscription in Germany, and the formation of an army 50 per cent. larger than the French. He also intimated that Germany had as large an air force as Great Britain, and aimed at parity with France. In October 1936 he signed a pact with Mussolini, recognizing the annexation of Abyssinia, and proclaiming the intention of their two governments to maintain the closest association in future, thus initiating a political and military alliance which came to be called the Rome-Berlin Axis.

All the powers began re-arming. Germany herself, having spent 617 million reichsmarks on armaments in 1931–32, spent openly 6,500 million in 1936–37. This re-armament drive in Germany, where Goebbels, director of propaganda, constantly preached a crusade on the text "guns before butter," caused a serious fall in the standard of living.

In November 1937 Italy recognized Manchukuo (*see* page 495) and joined the Anti-Comintern pact made between Germany and Japan in 1936. Franco adhered to it also, as soon as his government was established in 1939.

Hitler kept up continual vehement demands for the return of the former German colonies. At the beginning of 1937 he announced the removal of the German railways and the Reichsbank from international control, and formally withdrew Germany's signature from the declaration that Germany was responsible for the war of 1914. By his inflammatory speeches and other methods of propaganda he stirred up discontent among the German-speaking groups in the succession states and elsewhere.

Austria Swallowed Up

This led, early in 1938, to the arrest of the head of the proscribed Nazi party in Austria, and renewed disturbances in that unhappy country. Hitler sent an ultimatum making impossible demands on Austria, massed troops on the frontier, and within a few hours marched into Vienna, where, on March 12, his forces gave a demonstration of their might for the first time on foreign soil. Next day the Austrian republic ceased to exist and became a *Land* of the German Reich.

The Rape of Czechoslovakia

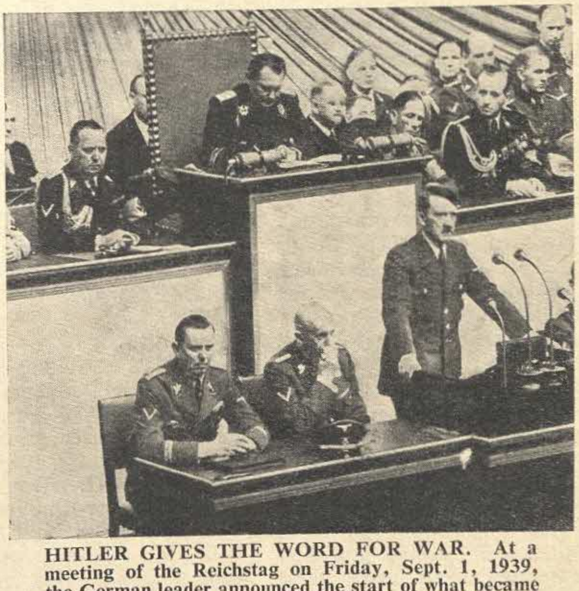
The German-speaking inhabitants of the Sudeten area of Bohemia were agitating for autonomy, accusing the Czechoslovak government of brutal ill-treatment; and the anxieties of that government were increased by similar demands from its Polish and Hungarian minorities, and by a protest from the Polish government alleging "Communist activities" inside Czechoslovakia against Poland. France in 1937 and again in 1938 assured Czechoslovakia that she would stand by their treaty of 1924 if Czechoslovakia were attacked, and the Soviet government in 1938 also gave her a pledge of immediate assistance in case of attack. As 1938 went on tension grew, not only in Czechoslovakia but in the rest of the world too. In September rioting broke out in the Sudeten area. Henlein, the Sudeten German leader, demanded inclusion in the Reich. His party was suspended, he himself fled to Germany.

In the midst of this tension Neville Chamberlain, the British prime minister, believing that war was all but inevitable, flew to Berchtesgaden to see Hitler. On his return, Daladier, the French premier, and Bonnet, the French foreign minister, flew to London. Under joint pressure from France and Great Britain, Czechoslovakia agreed to the cession to the Reich without plebiscite of areas including more than 50 per cent. Sudeten-Germans, and the neutralisation of the rest of the country. Chamberlain flew to Godesberg for a second meeting with Hitler, who now insisted on the handing over by October 1 of very considerable areas shown on a map he presented. Back in London, Chamberlain once more met Daladier and Bonnet—and at Munich on September 29 at a meeting between Hitler, Mussolini, Chamberlain, and Daladier, to which no Czechoslovak representative was admitted, the dismemberment of Czechoslovakia was confirmed.

The Czechoslovak government announced "after having considered the decisions of the conference in Munich, taken without and against it, it finds no other means but to accept, and has nothing to add." Next day Teschen was ceded to Poland, and soon agitation began in Slovakia for autonomy, and then for independence. The Germans still left in Czechoslovakia complained to the Reich that their position was untenable—and in March 1939 Hitler expressed his "decision to take the Czech people under the protection of the Reich." By the threat that he would send 800 aeroplanes to bomb Prague he broke the resistance of the government, and took possession of Bohemia and Moravia. Slovakia, which had declared its independence, was immediately placed under his protection by its new premier.

Annexation of Memel

A few days later Hitler annexed Memel, which since 1924 had been an autonomous unit of Lithuania; and shrill accusations of maltreatment of the German minority in Poland began to be hurled against the Polish government by the German press. Colonel Beck, the Polish foreign minister, came to London, and as a result of negotiations Chamberlain announced on April 6, 1939, that in the event of violation of Polish territorial integrity, Great Britain would give full support to the Polish government. Germany replied by denouncing the Anglo-German naval agreement of 1935 (which had limited Germany's total naval tonnage to 35 per cent., her submarine tonnage to 45 per cent., of those of the British Commonwealth of Nations), and her non-aggression treaty with Poland of 1934.



HITLER GIVES THE WORD FOR WAR. At a meeting of the Reichstag on Friday, Sept. 1, 1939, the German leader announced the start of what became the Second World War. Goering, sitting behind him, was nominated his successor.

The U.S.S.R. had been steadily pursuing her plans for internal development. In 1936 a revised constitution was introduced; it included guarantees of freedom of speech, of the press, of meetings and of processions, the right to work and to rest, the right to material security in old age and to education, equality independent of sex, nationality, and race; and it abolished the system of indirect election of the praesidium—the "soviet system"—in favour of direct election to that body. All citizens of 18 and upwards were given a vote. At the elections of December 1937, 96·8 per cent. of the 94½ million enfranchised persons voted, although the only possibility was to vote for the unopposed official nominee in each single-member constituency.

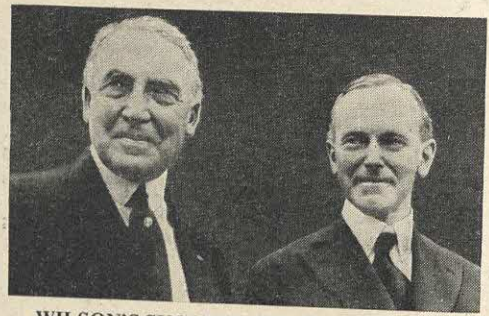
The year 1937 saw the trial of 17 Russian leaders, including the well-known Radek and Sokolnikov, a former ambassador to Great Britain. All the accused admitted their guilt on charges of espionage, wrecking, and angling for German and Japanese support in schemes against the Soviet government. Thirteen were shot, Radek and Sokolnikov being condemned to imprisonment for 8–10 years. A few months later a number of highly placed army officers were shot for betraying military secrets to, and conspiring with, Germany. During that same year the second Five Year Plan was completed, a year ahead of schedule; and the third Five Year Plan was inaugurated.

The attacks in the German press on the Polish government continued, and international tension reached bursting point when in August the U.S.S.R., against whom Hitler had never tired of fulminating as the arch-enemy of mankind, concluded first a trade and credit agreement, and then on the 23rd a pact of non-aggression with Germany. Next day, Great Britain and Poland signed a pact of mutual assistance. One week later, on August 31, the German government issued over the radio a 16-point "plan" for a settlement with Poland, including the unconditional return to the Reich of the Free City of Danzig. Without the issue of an ultimatum, without a declaration of war, German troops poured into Poland, and German planes began to bomb Polish cities on September 1, 1939. The Second World War had begun.

LESSON 29

America and the Pacific Between the Wars

THE statesman responsible for bringing the League of Nations to birth was Woodrow Wilson, president of the United States. The League idea was a logical development of American belief in arbitration. But while Wilson succeeded, after considerable difficulty, in persuading the other delegates to the Versailles conference to accept the League idea, and got it introduced into the texture of the peace treaties signed by the European powers, he returned to the United States to face fierce and general hostility. Though the treaties never failed to secure a majority in the Senate the two-thirds majority necessary for their ratification could not be obtained, and the United States remained technically at war until October 1921, when special treaties of peace, negotiated with Germany, Austria, and Hungary under Wilson's successor, President Harding, were ratified. On the cessation of hostilities the United States returned determinedly to a policy of isolation. She steadfastly refused to join the League of Nations; though she consented eventually to appoint "observers" to certain of the commissions (e.g. that on the opium traffic) set up by the League. The League never overcame this initial handicap.



WILSON'S SUCCESSORS. Warren Gamaliel Harding, president 1921–23 (left), and Calvin Coolidge, vice-president 1921–23, who first became president on Harding's sudden death.

For ten years the policy of isolation seemed justified, for the United States enjoyed a period of unprecedented prosperity. That is to say, "big business" did. The stock markets soared, wealthy men and women and corporations grew wealthier, and President Hoover when he took office in 1929 said, "We in America are nearer to the final triumph over poverty than ever before in the history of any land." Yet throughout the decade there had been an average of nearly two million unemployed; the farmers were in desperate straits—by 1930 four-fifths of all farms were occupied by tenants, and between 1927 and 1932 mortgages were foreclosed on one-tenth of the farmland of the United States. The "big business" administrations of Harding, Coolidge, and Hoover did not understand farming and had no interest in the farmer. His great need was to find markets abroad; but high tariffs on manufactured goods imposed in 1921, and again in 1930, prevented the import of the things Europe wanted to supply in exchange for the produce the farmer wanted to sell. These high tariffs assisted industry; but they injured the farmer—and even in 1930 a quarter of the population was engaged in agriculture.

U.S.A. a Creditor of Europe

Peace found the United States for the first time in the position of a creditor instead of a debtor nation, owing first to the sale by the Allies of their pre-war American holdings, and secondly to their heavy borrowing during the war. Europe could not pay her debts because she could not sell her manufactures, and these two facts were symptoms of the general financial chaos that afflicted the whole world. Germany defaulted, and in 1924 a commission headed by Charles G. Dawes worked out a scheme for securing payment by a lien on German railways and factories. Thereafter German indebtedness to America was doubled by the investment of millions of dollars of private capital in German municipal and corporate securities. In 1923 the United States made a settlement with Great Britain under which the British debt was to be repaid in annual instalments over a long period, the total repayment amounting to about 80 per cent. of her obligations. Similar arrangements were made with other Allied debtors. Friction over debts helped to increase the tendency in the United States to isolation, and to create a spirit of hostility towards Europe.

Prohibition

America had long shown an inclination to prohibit the consumption of alcohol. As far back as 1890 Congress had forbidden the carriage of intoxicating liquor into prohibition states—which by 1917 meant more than half the states. The War Prohibition Act, introduced as a war-time measure to conserve grain, was not passed by Congress until November 1918; it was put into effect June 30, 1919. Prohibitionists had meantime succeeded in getting prohibition into the Constitution: the 18th Amendment, prohibiting the manufacture, sale, or transport of intoxicating liquors in the United States and territories subject to U.S. jurisdiction had been approved by 36 states by January 1919, and was eventually approved by 46 out of the 48 ; it was made effective by the Volstead Act in January 1920. Yet in spite of the overwhelming apparent support for the measure, organized evasion of the law started immediately—and among normally law-abiding citizens, with the unfortunate result that the law as a whole was brought into contempt, and an era of gangsterdom in the big cities set in such as the world had not seen since the Middle Ages. The 21st Amendment, adopted in 1933, repealed the 18th.

The years following the First World War marked a great change in United States policy towards immigration. From 1918 onwards conditions of entry were stiffened, to reduce the number of "undesirables" entering the country, and an act of 1924 introduced a permanent quota system, under which only 2 per cent. of the number of persons of a given nationality in the United States in 1890 were permitted to enter in each year. The total number of immigrants allowed from countries other than Canada and Mexico (from which unrestricted immigration was still allowed) was thus reduced to 165,000 a year. (In the years immediately before the war, the average had been a million a year.) The United States thus ceased to be the haven of refuge towards which the oppressed and the ill-adjusted of the old Continent turned hopeful eyes—indeed, during some years of the great depression emigration from the U.S.A. exceeded immigration into it.

The Great Depression

Hoover's optimistic forecast of final triumph over poverty proved lamentably ill-timed, for in October 1929 occurred the greatest economic catastrophe the world had ever seen. The bottom dropped out of the stock market, and the artificial prosperity of the '20s vanished overnight. Thousands of banks and businesses closed, and within a few weeks millions of men and women were walking the streets searching, in vain, for work. America had known panics before, the effect of some of which had lasted for two—three—five years ; the panic of 1929 left a depression that lasted for ten years. By 1933, when Franklin D. Roosevelt took office as president for the first time, there were over 12 million unemployed, and stock exchange securities valued at 87,000,000,000 dollars in 1929 were worth only 19,000,000,000 dollars.

Harding, Coolidge, and Hoover, the three men who successively held the presidency between 1921 and 1933, represented business, and nothing more. Roosevelt had an understanding of world affairs, past and present, and ideas about the future. He was confronted by an immense task, and he set about it with immense energy. His "New Deal" aimed at securing a proper balance of interests throughout the state. He inaugurated measures both of relief and of reform. Certain rights were secured to the workers: the Wagner Act of 1935 gave them the right to form unions of their own choice ; the Fair Labor Standards Act of 1938 set up as a standard a 40-hour week with a minimum wage of 40 cents an hour, and abolished child labour in factories. Federal legislation of 1935 gave assistance to the unemployed, the aged, and the disabled. Employment was found for more than three millions in government relief and construction works. Help on a large scale was provided for farmers. Basic industries such as the railways, coal, and oil were helped to a sounder running. Federal assistance was given to literary, artistic, and theatrical enterprise. Banks and the stock market were brought under stricter supervision. The incidence of taxation was amended. Reforms were effected in administration.

F. D. ROOSEVELT (1882–1945), president of the U.S.A. 1933, re-elected 1936, 1940, and 1944. He initiated the "New Deal" policy.

Not all the measures introduced by President Roosevelt proved satisfactory ; but his policy did build up once more that sense of security among the people the loss of which had demoralised the whole life of the country. By 1939 the United States was slowly recovering : then war broke out in Europe once more.

Latin America

The entry of the United States into the First World War greatly enhanced her prestige in the 20 republics of Central and South America, eight of which (including Brazil) followed her example and declared war on the Central Powers. The change in the balance of world finance resulting from the conflict altered the financial influences at work in Latin America. Before 1914 Great Britain had invested in Latin America far more capital than any other country. After 1918 British capital continued to exceed American in South America ; but American investment in Central America increased so rapidly that the total United States capital invested in the 20 republics exceeded the total British capital. The countries of the Caribbean area became more and more closely dependent on the United States.

During the period between the world wars Latin America steadily developed towards stable government—by dictatorship, but with a leaning towards democracy. Economic development continued too, with an increasing trend towards industrialisation that had been given a strong impetus by the cutting off of manufactured goods from Europe during the First World War.

MAKERS OF A NEW CHINA. Left, Dr. Sun Yat-sen (1866–1925), organizer of the revolutionary party that overthrew the Manchu dynasty, 1911–12. Right, General Chiang Kai-shek, leader of the nationalist party (Kuomintang) and president of China from 1943 to 1949.

The increasing support given by Latin America, with strong United States backing, to the Pan-American idea (*see* page 477) did not obviate all South American international difficulties. The long-standing dispute between Chile and Peru over the ownership of the former Peruvian provinces of Arica and Tacna was at last settled through United States mediation in 1929. Chile had gained control of these provinces in 1883 on the understanding that their final fate should be settled by a plebiscite in 1893. The plebiscite had never been held; Chile had continued to hold them; Peru had continued to dispute her right to do so. Under the settlement reached in 1929 Arica was allotted to Chile, Tacna to Peru.

United States mediation also brought to an end the sanguinary war between Paraguay and Bolivia over the possession of part of the Gran Chaco, which had always been regarded as Paraguayan, but which in 1932 Bolivia attempted to seize by force. Bolivia, cut off from the Pacific by the loss of the province of Antofagasta in 1884, wanted to secure access to the Atlantic via a river port on the Paraguay. But her much better trained and equipped army failed to effect the rapid conquest she had expected. The war dragged on to a stalemate, and in 1935 the United States arranged a settlement confirming Paraguay in the possession of most of the area, but allotting to Bolivia a port on the River Paraguay with access through Paraguayan territory.

Mexico

The troubles in Mexico which followed the fall of General Diaz in 1910 did not come to an end till 1920, when a period of reconstruction began, based on a new constitution promulgated in 1917. This guaranteed the rights of labour common in progressive countries, and declared ownership of the land to be vested in the nation. In 1938 the foreign companies working Mexico's oil were expropriated; and by 1939 the government had made considerable headway with its programme of agricultural reform and educational development: the number of primary schools had increased from 7,500 in 1934 to 20,000 in 1940.

From the moment that Japan took the decision to abandon medievalism and adopt the mechanised civilization of the West, she set herself, quietly but determinedly, to become *the* power in the Pacific; and both Europe and the United States, befogged by fears of Russia and the "yellow peril" of China's millions, aided her undeclared ambition. Japan acquired a footing on the mainland in 1894, when she ousted China from Korea. She strengthened her hold when in 1905 she succeeded to Russia's rights in the Liaotung Peninsula and over the southern section of the Manchurian railway.

On the outbreak of the First World War Japan found herself, by virtue of the Anglo-Japanese alliance of 1902 (ended in 1923 by a treaty between U.S.A., France, the British Empire, and Japan), on the side of the Allies; and in August 1914, aided by a small British force, she seized Tsingtao and other German possessions in the province of Shantung (her occupation of these was confirmed in the treaty of Versailles).

Birth of a New China

China, urged on by the United States and Japan, declared war on Germany in 1917. But owing to the civil strife and disorder in which she had been plunged since the overthrow of the Manchu empire in 1911 (the emperor abdicated in 1912) she was in no condition to wage war. Japan, whose "special interests in China" had been recognized by the United States, increased her hold on the country; a Japanese adviser sat on the Chinese war participation board; China entered into agreements with Japan for mutual defence against possible invasion from the north (by Russia, after the revolution), and for the construction by Japan of railways in Shantung, Manchuria, and Mongolia. China also borrowed extensively from her neighbour.

The Washington Conference, 1921, of the powers interested in the Pacific, while declaring the intention of the participants—Great Britain, France, Italy, the Netherlands, Belgium, Portugal, China, and Japan—to respect the sovereignty, independence, and territorial and administrative integrity of China, at the same time urged China to reduce the large military forces maintained by the military (and quarrelsome) governors of her provinces. It also confirmed Japan in her domination of the north-eastern coast of China, though it decreed that the former German possessions in Shantung were to be returned to China. But Japan still retained large commercial interests in the province; and China added to her borrowings from Japan.

For some years Japan was more careful to observe China's rights. But, despite the rise of two leaders in the persons of Dr. Sun Yat-sen (died 1925) and General Chiang Kai-shek (whose wives were sisters), China was still in a state of chaos, and this gave Japan an excuse for re-occupying part of Shantung in 1928, to protect her interests. In 1931 Japan invaded Manchuria and set up a puppet state there under the name of Manchukuo. Japan's attack on, and dismemberment of, a fellow member of the League of Nations was heatedly discussed by a League meeting; but it did no more than pass a resolution recommending the non-recognition of Manchukuo. Japan, indeed, was proving herself a nation after Hitler's own heart, and in 1936 Hitler concluded with her the Anti-Comintern Pact, aimed against Russia. Manchukuo was recognized by Italy in 1937, by Germany in 1938.

What Japan persisted in calling "the China incident" began in 1937, when an exchange of shots between a Chinese garrison and Japanese troops engaged in manoeuvres outside Peking caused Japan to announce that she was obliged to reinforce her garrison in North China, owing to the grave situation there. Japan expected to secure control of disturbed China in a very short time; but the "incident" changed into a long-drawn-out though undeclared war.

LESSON 30

Second World War: Europe and Africa

GERMANY'S advance into Poland was swift and irresistible. She crossed the frontier on September 1, 1939, and four weeks later the campaign there was over. The German air force swept from the skies the few planes Poland possessed; and Warsaw was bombed mercilessly. German tanks overwhelmed the Polish cavalry—the greatest bravery was no match for machines. On September 17 Russian troops crossed Poland's eastern border. Caught between two advancing armies, the Poles were helpless. The government fled to Rumania, then to France (and eventually, in June 1940, to England); so did thousands of Polish soldiers. Warsaw surrendered on September 27, and on October 5 Hitler entered the city in triumph.

Germany and Russia, who had signed a non-aggression pact in August 1939, partitioned Poland between them along a line roughly following the rivers Pisa, Bug, and San. Russia followed up her acquisition of part of Poland by inducing Estonia, Latvia, and Lithuania (parts of the old Russian empire) first to allow her to place air and naval bases on their territory, and then to join the Union of Soviet Socialist Republics. Finland, similarly approached, resisted. A three months' war followed, Finland putting up an unexpectedly good defence. But she was overpowered, and Russia secured the desired bases and enough territory to provide a little cover, in case of attack, for the city of Leningrad which stood only some 25 miles from the former Russo-Finnish border.

In western Europe, a situation of stagnation developed after the paralysingly rapid fall of Poland. France waited behind the Maginot Line, the 250-mile line of defensive works she had constructed from the Belgian to the Swiss

HORSE ARTILLERY AGAINST NAZI ARMOUR. On Sept. 1, 1939, German tanks poured across the frontier and overwhelmed the Polish cavalry and horse artillery who tried with unsurpassed valour to stem the Nazi advance; but courage was no match for tanks and planes.

NARVIK FJORD—THROUGH GERMAN EYES. After this battle a German destroyer was boarded by the British and a camera with an exposed film was found on board. Here is one of the photographs, showing the landing of German troops at Narvik.

frontiers during 1929–36. Germany appeared to be waiting behind her parallel Siegfried Line. Alongside the French forces stood a British expeditionary force of 250,000 which, with all its transport and equipment, had crossed the Channel by the middle of September. There were occasional skirmishes in the no-man's-land between the Maginot and Siegfried Lines ; but the " war of movement " had come to a stop. Switzerland, Scandinavia, and the Low Countries continued to maintain their neutrality.

Conquest of Norway and the Low Countries

Then the Germans struck again. On April 9, 1940, they invaded Denmark, which, having no defences, offered no resistance. From Denmark they swept across the Skagerrak to Norway, and in a month had conquered that country. On May 10 they attacked the Netherlands, Belgium, and Luxemburg simultaneously.

Parachutists and airborne troops, landed far from the frontier, played a considerable part in both the Norwegian and the Low Countries campaigns. They carried out acts of sabotage, and issued orders purporting to come from the local authorities, thus causing confusion and dismay. In these small countries there proved to be men who had been weaned from their national loyalty—some by a genuine belief in Nazi revolutionary theories. Norway alone, however, produced a man willing to deputise for the Nazis in the government of his occupied country ; his name, Quisling, added a new word of scorn to many languages.

By May 13 German armoured divisions were pouring into France : for the Maginot Line stopped at the point where the frontiers of France, Luxemburg, and Belgium meet, and the Germans simply outflanked it, getting control of it later from the French side. Germany's air force demonstrated its might by a concentrated attack on Rotterdam (May 14) in which the whole centre of the town was levelled to the ground and several thousand civilians were killed. On the same day the small Netherlands army, without air support and pursued beyond its last defences, surrendered. The Belgian army, with Allied support, fought on till May 28.

Dunkirk

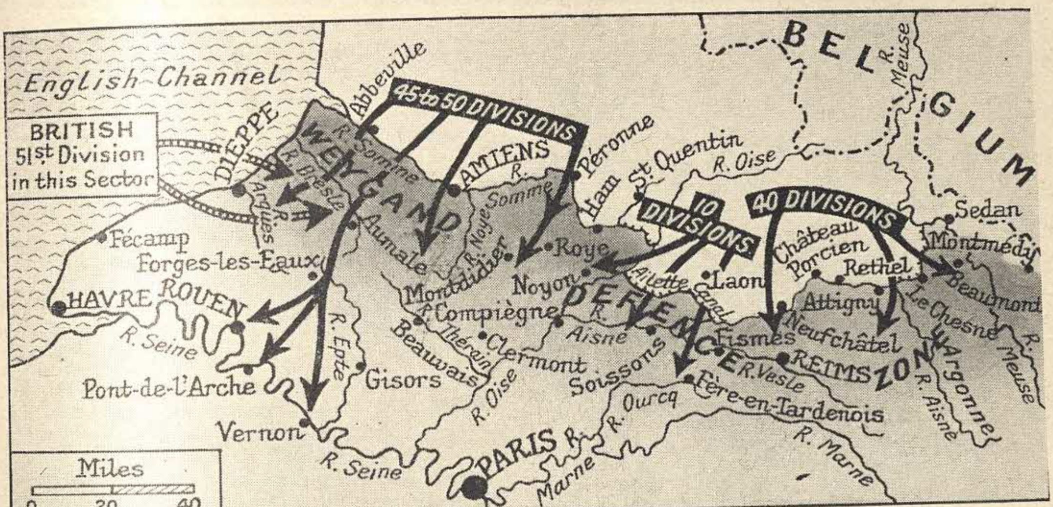
The collapse of the Belgians, and the sweeping advance of the Germans, left the British penned up in a corner behind Dunkirk. It looked as though the entire British expeditionary force would fall prisoner to the Germans. But in what Winston Churchill, British prime minister, called a " miracle of deliverance," some 225,000 out of a total of 250,000, together with half as many again of Allied troops, were safely evacuated to England.

Germans Enter Paris

Relentlessly the Germans pushed on through France. Hampered by thousands of refugees fleeing along the roads before the invader, hammered by the German air force, pursued by German armour, the French forces retreated southward. Surrender looked inevitable. Italy chose this dire moment to declare war on France and Great Britain on June 10, and invaded the south of France. The French government moved to Tours the same day and then on June 15 to Bordeaux. On June 13 Paris was declared an open city, and the French fell back behind it. Next day the Germans entered Paris. Bewildered, uncomprehending, imagining (many of them) that Great Britain had deserted them, the French people seemed to lose all power of resistance. Churchill's extraordinary offer on June 16 of union between France and Great Britain was kept from them. There was no cohesion among French leaders, political or military, though large sections of the army, ill-equipped and without armour, fought heroically.

Defeat of France

The Reynaud government fell, and Pétain, hero of Verdun in the First World War, and now a marshal of France, took charge. On June 17 he asked for an armistice, which was signed on June 22 at Compiègne in the presence of Hitler, and in the same railway coach in which the armistice of November 1918 had been signed by defeated Germany. The conditions were humiliating. They included the demobilisation



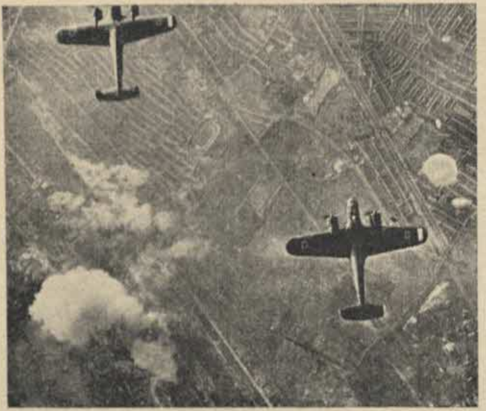
WHERE THE NAZIS STRUCK. This map of the Weygand Defence Zone shows the main points from which the Germans developed their final offensive during the Battle of France. The line along which General Weygand tried to establish his armies traversed northern France from the estuary of the Somme to the first forts of the Maginot Line proper near Montmédy. The Germans reached this zone by June 10, 1940 ; the hinge of the line at Sedan broke at the first thrust and four days later they entered Paris.

of all French forces ; the disarming of the French fleet, except for such ships as might be required to defend the French empire overseas ; control by Germany of aerodromes, military stores, ports, and fortifications ; and the occupation of all that part of France lying along the Channel and Atlantic coasts, to a depth that included Paris, Dijon, Tours, Bordeaux, and many other of the most important cities and industrial regions. A semi-Fascist government set up at Vichy under Marshal Pétain had little freedom of action. One and a quarter million French soldiers were prisoners of war, and by alternating threats and promises in regard to these men Hitler kept the Vichy government completely under his thumb.

Battle of Britain

Except for Sweden, Switzerland, Greece, and the Iberian Peninsula, Germany and her allies and satellites now controlled all Europe west of

GERMANS IN PARIS. Soon after 7 a.m. on June 14, 1940, the first German troops—armoured motor cyclists—entered the city, and three hours later goose-stepping columns marched through the empty streets. Above are two infantrymen on patrol near the Arc de Triomphe,



GERMAN BOMBS ON LONDON. Two Dornier 217s flying above fires started by bombs. During the Battle of Britain the Germans used also the Dornier 17, Junkers 87 and 88, and Heinkel 111K.

Russia. But, contrary to anticipations on the Continent and in the United States, Great Britain did not follow France's example and ask for an armistice. The "Battle of Britain" began in August with heavy daylight air raids on shipping and on ports, airfields, and industrial districts, and continued till the turn of the year. The temper of the people stood ; and in the spring of 1941 Hitler, balked of what had seemed easy prey, turned his attention to the Balkans.

War in Greece

There, since October 1940, the Italians had been trying in vain to subjugate Greece. In April 1941 German armed forces already in Rumania (an Axis partner with Hungary since November 1940) and Bulgaria (who joined the Axis in March 1941) swept simultaneously and without any declaration of war over Yugoslavia and Greece, and went on to capture Crete. A large part of the small British, New Zealand, and Australian force which had helped to defend Greece, and, after the fall of Athens on April 27, had retired to Crete, was evacuated to Egypt in the last days of May. The British navy, after damage and losses inflicted on the Italian fleet by the air attack on Taranto and the battle of Matapan, was in command of the sea, though it suffered heavily from air assault in this evacuation.

Attack on Russia

Once more there was a brief lull in Europe ; and then on June 22 Germany without warning attacked Russia. Immediately Churchill announced that Great Britain and Russia were at one in the struggle, and that Britain would render Russia and the Russian people all the help she could. Finland, still smarting from her defeat of the previous year, joined Germany. The Russians fell back and back, leaving little for the enemy's comfort, in pursuance of their avowed " scorched earth " policy. Before the winter set in the Germans were in places only 15 miles from Moscow and had reached the outer defences of Leningrad in the north, of Rostov-on-Don in the south. But they failed to capture Moscow, and that winter, one of the bitterest on record, gave the Russians, accustomed to, and equipped to meet, the cold, an advantage of which they made full use : they drove the Germans back—not, it is true, more than a fraction of the way they had advanced ; but for the first time the Germans had to retreat.

With the coming of spring in 1942 the Germans advanced again, more particularly in the south towards the Caucasian oilfields—which, however, they did not reach. They captured the Crimea, taking Sevastopol after a siege that lasted eight months ; and they pushed on towards Stalingrad, the great industrial town on the Volga on which the Russian forces had depended for important supplies. The Germans penetrated the outskirts of the city in September, and kept announcing that Stalingrad was about to fall—but, so fierce and steadfast were its defenders, it never did ; and in February 1943 the Germans still there capitulated.

Once more the Germans were forced to retreat. All along the line they retreated, though they continued to hold several important centres lying in enclaves in the Russian advance. Leningrad, which for 16 months had been almost surrounded, was relieved in January 1943, and access regained to it by land—during the siege the only access had been across Lake Ladoga. Rostov-on-Don was recovered in February. Local activity on a smaller scale continued, until in July the Germans launched a major but unsuccessful attack in the neighbourhood of Orel. Russia's political relations with her allies were much improved by the dissolution (June 1943) of the Comintern.

JOSEPH STALIN, dictator of Russia from 1924 until his death in 1953. This likeness is from a portrait by Karpov.

The losses on both sides in the Russian campaign were colossal—on the first anniversary of the invasion Moscow announced the casualties as 10,000,000 Germans, of whom 3,500,000 were given as killed, and 4,500,000 Russians. Losses of material were on a commensurate scale. After the bitter experiences of the west no one expected Russia to withstand the German onslaught. That she did was due to a number of things : her immense distances, which gave her possibilities of strategic retreat denied to the western armies ; the stability of her government ; the unsuspected resource and devotion of her people, the unsuspected excellence of her material ; the methodical removal from the areas left to German occupation of plant, machinery, and skilled workers to "shadow" factories organized with astonishing efficiency in the Urals and districts in Asia far even from the most advanced line that the front reached ; and the supplies, particularly of aeroplanes, which Great Britain (and later the United States) were able to get through to her.

German Retreat Continues

A short spell of merely local actions in Russia followed the Germans' abortive offensive round Orel, and then in September 1943 the Russians began a series of attacks before which the Germans retreated all along the line. Stalino, the Donbas area, Mariupol on the Sea of Azov, Novorossiisk in the Kuban, Briansk on the River Desna were recovered. On September 19 alone the Russians recaptured over 1,200 hamlets, villages, towns, and railway stations on a 500-mile front extending from Roslavl to the Kuban. September 25, 1943, saw the recapture of Smolensk, which had fallen into the hands of the enemy 55 days after the invasion began. Dnepropetrovsk was taken by storm on October 25 ; and the enemy's last land retreat from the Crimea was cut off on November 1 by the recapture of Perekop and Armiansk.

Kiev, Russia's oldest city, was recaptured on November 6, by which date, since July 5, the Red Army had liberated 140,000 square miles of territory and advanced some 180–280 miles on a 1,200 mile front. Gomel was recaptured on November 26 ; and then, at the beginning of December, the Russians were forced to abandon a few places on the Kiev salient. Tank battles in this area reached a pitch of unsurpassed violence ; but, by the 18th, Von Manstein's German forces were halted, and on the 26th the Russian commander Vatutin went over once more to the offensive, sweeping on so impetuously that on December 31 he recaptured Zhitomir. The new year opened with the German armies in the Ukraine everywhere in full retreat.

DEFENDERS OF STALINGRAD. The failure of the Germans to take Stalingrad at the end of 1942, thanks to the stubborn and heroic resistance of its defenders, marked the turn of the tide in Europe in the Second World War.

THE EMPEROR RETURNS. On May 5, 1941, Haile Selassie entered Addis Ababa, capital of Abyssinia, after five years of exile. He is seen here, followed by the Crown Prince, making his way to his palace.

Fighting in Africa

Italy followed her declaration of war on June 10, 1940, by invading Kenya, the Anglo-Egyptian Sudan, and British Somaliland. The campaign in Somaliland lasted a fortnight; the British evacuated British Somaliland on August 19, 1940, retiring on Aden, and the Italians occupied Kassala, Gallabat, and Kurmuk in the Sudan, Moyale and El Wak in Kenya. But by the middle of February 1941 the Italians had been driven back across the frontiers of Kenya and the Sudan, and the British were advancing from Kenya into Italian Somaliland, where before the end of the month they had overcome all resistance. They then turned northwards to Abyssinia. During five days of March the British regained control of British Somaliland, and then advanced into Abyssinia ; they also crossed from the Sudan into Eritrea, and put an end to Italian resistance there with the capture of Massawa on April 8. That left all the British, South African, Indian, and Free French forces in East Africa free to liberate Abyssinia.

SECOND CAPTURE OF BENGHAZI. On Christmas Eve, 1941, units of General Ritchie's Eighth Army entered Benghazi: here armoured cars of the South African Field Force are seen passing into the city. By January 29 British forces had again retreated before Rommel's successful drive from El Agheila.

Abyssinian Emperor Returns

Abyssinians, trained and encouraged by a British mission, and with air assistance from the South Africans and Free French, had already gained control of the Gojjam, a wild and mountainous region between the Sudan frontier and Addis Ababa, itself captured on April 5 by the British forces advancing from British Somaliland. On May 5 the emperor Haile Selassie re-entered his capital exactly five years after it had been seized by Italy. The Duke of Aosta, Italian viceroy and commander-in-chief, retired to Amba Alagi, the rugged mountain in whose caves the emperor had sheltered five years before. He asked for an armistice on May 16, and surrendered unconditionally with 18,000 men. With the fall of Gondar on November 27 Italian rule in Abyssinia, and Italy's East African empire, came to an end.

While these events were going on in East Africa, Italian and British forces came into conflict also along the Libyan-Egyptian border. Great Britain's relations with Egypt were governed by a treaty made in 1936, which ended British occupation but gave Britain the right to maintain 10,000 troops and 400 aircraft in the Suez Canal zone, and provided for military co-operation in the Sudan. The British garrison had been increased since the beginning of the war, chiefly by volunteer forces from Australia and New Zealand. But though Egypt was garrisoned by British troops, and the ports of Alexandria and Port Said were open to the British fleet, Egypt was not at war with the Axis. However, in September 1940 Italy invaded Egypt and the British fell back on Mersah Matruh.

DESERT WARFARE. British transport advances into Libya during the first invasion of Italian territory from Egypt in December 1940. A bomb dropped from an aeroplane explodes ahead on the recently constructed road across the desert. The Italians were temporarily driven back to Benghazi.

Three months later, the British under General Wavell launched a surprise attack, sweeping the Italians back to Benghazi, which was captured on February 6, 1941. The withdrawal of British troops for the ill-fated campaign in Greece left Wavell too weak to go farther, too weak, indeed, to hold what he had gained, and by the end of April the enemy was back at Sollum, over the Egyptian border. Tobruk alone of the British conquests remained in British hands. In November the British, commanded now by General Auchinleck, advanced again. The siege of Tobruk was lifted, Benghazi was recaptured, and El Agheila was reached on

January 18, 1942. But events in the Far East led to the withdrawal of seasoned Australian troops from the North African front, and by July 1 a counter-offensive under the German General Rommel had driven the British back to Alamein in Egypt.

FREE FRANCE. King George VI and General de Gaulle, organizer of the Free French National Committee, taking the salute at a review of Free French forces in England, August 24, 1940.

Fighting France

General de Gaulle, a pioneer writer on tank warfare, and a member of Reynaud's government in 1940, had carried Churchill's offer of Anglo-French Union to Bordeaux. He returned at once to England when Pétain asked the Germans for an armistice, and called on all Frenchmen outside the jurisdiction of the Bordeaux government to continue resistance. The Free French National Committee, with de Gaulle at its head, was set up in London. French ships in English ports and at Alexandria formed the beginnings of a Free French navy.

By the end of the year the New Hebrides, Tahiti, New Caledonia, the Chad Territory, the Cameroons, French Equatorial Africa, and the French establishments in India had adhered to Free France (renamed Fighting France on July 14, 1942).

Insurrection in Syria against Vichy France, and the discovery that the Vichy authorities were allowing Syrian aerodromes to be used by German planes and were aiding pro-Nazi rebels in Iraq, led to the occupation of Syria by British and Free French forces (July 12, 1941). Its administration was handed over to Free France.

LESSON 31

Second World War: The Americas, the Pacific, and the Mediterranean

The outbreak of war in Europe strengthened isolationist opinion in the United States. America's determination to maintain neutrality in all extra-American conflicts had been embodied in the Neutrality Act of 1935, which forbade the export of arms and ammunition to any belligerent. An act of 1937 renewed the embargo on arms, empowered the president to prohibit the export of other articles as well to a belligerent, and laid it down that permitted articles could be supplied only on a cash-and-carry basis : that is, the purchaser must pay in dollars, and must fetch the goods. In November 1939 a further Neutrality Act modified the position by permitting belligerents to buy war materials, but only on a cash-and-carry basis : while it forbade United States vessels to handle war cargoes, be armed, or enter any combat area. This meant, in fact, that only Great Britain could buy arms in the United States, for Germany possessed neither the cash nor the necessary ships, and when Britain proceeded to spend four thousand million dollars on arms, many Americans were afraid that American neutrality was being broken. But President Roosevelt, more far-seeing than his countrymen, refused to be swayed in his policy which, from the beginning, leaned towards support of the democracies. The stagnation that followed the conquest of Poland led a great many American people to regard the European situation with the greatest distrust. They felt that the war was somehow a " put-up " job, that the threat from Germany was absurdly exaggerated, that Great Britain and France had no serious intention of fighting ; and that the whole thing was a long way away and no concern of the United States. But the ruthless disregard by the Germans of the carefully preserved neutrality of Scandinavia and the Low Countries opened many eyes to the fact that the strictest neutrality was not enough. Fear of what Germany might achieve grew with the crumbling of French resistance ; and disgust flamed at Italy's stab in the back of defeated France. On May 10, 1940, Roosevelt obtained a thousand million dollars for defence ; on May 28 he set up a Council of National Defence ; and in September an act was passed compelling every male citizen and resident alien between 21 and 36 to register with liability to military service if selected under the ballot system set up by the act.

Anxiously the United States watched Britain ; but as the Battle of Britain progressed she realized with immense relief that western civilization had an active defender. Roosevelt, with the backing of the majority of his countrymen, promised " all aid to Britain short of war;"

THE ATLANTIC CHARTER. In August 1941, historic meetings between Winston Churchill and President Roosevelt aboard H.M.S. "Prince of Wales" in the west Atlantic led to their broadcasting of the declaration called the Atlantic Charter.

but the Johnson Act of 1934, which prohibited the making of loans to countries that had defaulted on debts incurred during the war of 1914–18, seriously hampered the provision of aid, for Great Britain's hoard of dollars was not equal to her needs. In September 1940, therefore, Roosevelt arranged a "deal": 50 superannuated destroyers in exchange for a 99-year lease of eight British places suitable for military bases on the Atlantic coast from Newfoundland to British Guiana.

Lease-Lend Act

In November 1940 Roosevelt won his third presidential election. Immensely strengthened, he was able in March 1941 to get passed the Lease-Lend Act which authorised the president to "sell, transfer, exchange, lease, lend, or otherwise dispose of any defence article" to the government of any country "whose defence he considered vital to the defence of the United States." In April all Italian and German ships in United States ports were seized, and in May all the assets of both countries in the United States were frozen. American troops were sent to Iceland in July 1941 to reinforce the British garrsion that had been there since May 1940 to prevent its seizure by Germany.

In August, less than two months after Germany's treacherous invasion of Russia, Roosevelt and Churchill met on board H.M.S. *Prince of Wales* in the west Atlantic, and issued what, from the place of its birth, was called the Atlantic Charter. This stated categorically that Britain and the United States sought no aggrandisement; that no territorial changes ought to be made without the freely expressed accord of the inhabitants; that all nations should have access to raw materials; and that all peoples should be entitled to choose their own form of government. The charter was the basis of the Washington Agreement, signed on January 1, 1942, by 26 Allied nations, subsequently called the United Nations. In November 1941 the provision of the Neutrality Act prohibiting the use of American vessels for transport of war materials was repealed; and Lease-Lend was extended to Russia.

Situation in China

In the Far East, war in China continued. By 1940 Japan had occupied most of the north of China and all the chief ports along her coast, as well as her main north-south railway lines. In September 1940, after the defeat of France, Japan invaded French Indo-China and began to set up aerodromes all along the frontier of Siam. The United States, which in 1939 had terminated its trade treaty with Japan, froze Japanese assets in America and stopped the export to Japan of scrap iron and steel. Japan retaliated by signing a pact of alliance with Germany and Italy. In April 1941, Russia signed a five years' non-aggression pact with Japan—a pact maintained until just before the end of the World War.

Pearl Harbor

Relations between Japan and the United States were not good; but they were still talking peace when, on December 7, 1941, without any warning Japan attacked the U.S. naval base of Pearl Harbor in the Hawaiian Islands. For the loss of three submarines and 41 aircraft, Japan destroyed one U.S. battleship and over 200 aircraft, and sank or put out of action many other warships. On the same day she seized the international settlement at Shanghai, and advanced from Indo-China into Siam, which after slight resistance joined her in the invasion next day of Malaya.

With what proved irresistible strength, the Japanese swept south, landing on Singapore Island exactly two months after their entry into Malaya. A week later came the fall of the great naval base of Singapore, which had cost £60,000,000 to construct. Churchill described it as "the scene of the greatest disaster to British arms which our history records." Sixty thousand troops were captured, including 40,000 men diverted to Malaya from other hard-pressed battle fronts. From Singapore the Japanese swept through the Netherlands Indies, where organised resistance came to an end in March. In less than four months Japan had conquered an immense empire, including the areas that produced 90 per cent. of the world's quinine, 80 per cent. of its rubber, and 64 per cent. of its tin.

Meanwhile, Hong Kong, attacked on December 8, 1941, fell on Christmas Day. Manila, capital of Luzon, where the Japanese made their first landing on December 11, held out till January 2, 1942, after which U.S. and Filipino forces withdrew to the Bataan Peninsula, where they maintained a heroic defence until April 8. Corregidor, an island fortress off Bataan, and the last piece of the Philippines in U.S. hands, held out a month longer. Burma, overrun from Siam and Malaya, was in enemy hands by May 15, 1942. Japanese occupation of Rabaul in New Britain in January 1942, of Lae and Salamaua in New Guinea in March 1942 threatened imminent danger to Australia.

Congress at War

The Japanese attack on the U.S.A. shook the American people awake. On December 8, 1941, Congress declared war on Japan, with only one dissentient voice; the vote which accepted a declaration of war by Germany and Italy was unanimous. Churchill with his chiefs of staff arrived in the United States on December 22 for consultations, which resulted in a Grand Alliance of 26 nations against the Axis, all pledged to support the terms of the Atlantic Charter. The United States with great energy began forming and equipping a large army and air force, and reinforcing its navy. The formidable success of the Japanese, whom the Americans had never regarded as a very serious danger, was a profound shock, and it led opinion for a time to swing to the other extreme and regard them as invincible. Fear in the United States, and in Canada, redoubled when in June the Japanese seized Attu and Kiska in the Aleutian Islands.

FALL OF SINGAPORE. The great British naval base surrendered on February 15, 1942. Here Japanese one-man tanks are crossing the Johore Strait by the causeway from Johore Bahru to the island of Singapore.

PEARL HARBOR WRECKAGE. Without any declaration of war, Japanese seaborne aircraft attacked the American naval base at Pearl Harbor, Hawaii, on Dec. 7, 1941. Fifteen U.S. warships, including the two destroyers in the foreground here, were destroyed, sunk, or disabled.

Japanese Reverses at Sea

But a change was coming over the Pacific scene. Tokyo, Nagoya, Kobe, and Osaka were bombed in April by aeroplanes flown from an American aircraft carrier. From the beginning Japan had met with reverses at sea. The Dutch, British, and Americans sank and damaged many of her naval and transport ships in battles in the Macassar Straits and other channels among the Netherlands Indies, and in May 1942 a Japanese fleet moving southward through the Coral Sea was forced to turn back by United States and Australian naval and air attack. Between Dec. 7, 1941, and June 1942, more than 230 Japanese ships were sunk or damaged, as against some 60 Allied vessels.

TANKS IN NEW GUINEA. The Australians who re-conquered N.E. New Guinea from the Japanese were supplied with General Stuart tanks, some of which are seen here in a coconut plantation at Cape Endaiadere (near Buna), where they had been landed in December 1942.

Pacific War Council

A Pacific War Council was set up in Washington in April 1942 ; Allied military operations in the Pacific were directed from headquarters in Australia. The Japanese were forced back out of Papua (South-East New Guinea) by January 1943, and out of Guadalcanal in the Solomons in February. In March a Japanese convoy of 11 transports and 10 warships was sunk by Allied bombers.

The relative weight of air attack changed, and the Allies bombed Japanese airfields and installations in the Netherlands Indies from Australia, in Burma from India, and in the Aleutians from Alaska more and still more heavily.

Paramushiri, northernmost of the Kurile Islands and a part of the Japanese homeland, was bombed in July 1943. Attu, westernmost of the Aleutians, was recaptured on June 5, and with the reoccupation of Kiska, on August 15, the whole Aleutian chain was once more in allied hands. In the South Pacific the Americans secured control of New Georgia by the end of August 1943. September brought large scale landings, predominantly Australian, in the Gulf of Huon (New Guinea), east of Lae. Salamaua airfield was captured on September 13, Salamaua itself next day after a Japanese occupation lasting 18 months. Lae fell on September 13, Finschhafen on October 2 after 11 days' heavy fighting, Sattelberg on November 26, Wareo on December 8, Lakona on December 15, 1943.

Campaign in New Guinea

The Australian campaign in New Guinea was one of the most brilliant in the history of jungle warfare. All food, supplies, water, and munitions had to be carried along paths hacked out step by step through the thick jungle undergrowth, in the face of strong enemy resistance. The Americans' success in driving the Japanese from the three-mile-long Arawe Isthmus of New Britain by December 18 gave the Allies command of the Vitiaz Straits between New Guinea and New Britain. United States Marines made successful landings in Bougainville, most northerly of the Solomons, on November 1, and by November 25 American headquarters was able to report that "few live Japanese remain in the Gilberts," a group of islands 1,000 miles north-east of the Solomons. Systematic air attacks were made against the important Japanese bases of Wewak in New Guinea and Rabaul in New Britain, and an air offensive was successfully developed against

AMERICANS LAND ON GUADALCANAL. The first major Allied success in the Pacific was the re-conquest of the island of Guadalcanal in the Solomons by U.S. forces, which began on August 7, 1942, and ended only on February 10, 1943 ; the picture shows U.S. Marines landing near Lunga Point.

the Marshall Islands, to the north-west of the Gilberts.

Allied military activity in Burma during 1943 took two principal forms : the advance from Ledo in Assam, begun in December 1942, through the enemy-infested forests of the north, of the American General Stilwell in command of a mixed British, U.S., and Chinese column, building as he went a road designed to link beleaguered China once more with the rest of the Allies ; and a daring marauding expedition into enemy-occupied territory carried out under the command of Brigadier O. C. Wingate, D.S.O., one of the British officers who had helped to organize resistance among Abyssinians in the wild region of the Gojjam. Starting on February 16, 1943, Wingate led his small force of "Chindits," as they were called after the fabulous griffins which guard the Burmese temples, to the Chindwin valley in the wild jungle country of central Burma. For three months they carried on wrecking operations far behind the enemy's lines—penetrating indeed to within 50 miles of Mandalay. They blew up the Mandalay-Myitkyina railway in 75 places, destroyed four bridges, started a landslide which blocked the Bongyanny gorge, did other substantial damage to enemy installations and communications, and kept 15,000 Japanese troops hunting vainly for them in the forest.

" CHINDITS " IN BURMA. A column of Major-General Wingate's jungle raiders, called after the griffin-like figures outside Burmese temples, fording a river in enemy-occupied country. In one raid occupying 58 days the Chindits blew up the Mandalay-Myitkyina railway in 75 places, and destroyed four bridges.

Allied Conquest of North Africa

The efforts of the United States were not confined to the Pacific area. Gradually, with very small losses, an American army was transported to Britain, and a commander of

ALLIED LANDINGS IN NORTH AFRICA. Part of the armada—at the time the largest ever assembled in history—which at 1 a.m. on Nov. 8, 1942, landed Allied troops at three points on the coast of French North Africa. It consisted of some 500 transports and was escorted by more than 350 vessels of the Royal Navy and the U.S. Navy. Troops (the majority American) were landed at Casablanca in French Morocco, and at Oran and Algiers in Algeria.

THE BATTLE OF THE KASSERINE PASS. After making a thrust towards Sfax, the Allies in Tunisia were in mid-February 1943 forced to withdraw through the Kasserine Pass towards Tebessa. They re-occupied the pass on February 25. Here Grenadiers are bringing up their Bren-gun carriers towards the pass.

the European theatre of war, General Eisenhower, was appointed. On October 23, 1942, the British under Lt.-General Montgomery launched a new offensive against Rommel from Alamein in Egypt. It proved to be an attack of unprecedented speed, strength, and ferocity. By November 7 Rommel had been driven back 240 miles ; he had lost half his tank force, a large part of his air support, and more than half his men. Next day, a combined force of British and Americans under the command of General Eisenhower landed in French North Africa. This invasion, involving 500 transports and 350 warships assembled from different quarters of the globe, was carried through with perfect timing, without a hitch, and with little opposition : in less than 76 hours the whole of Algeria and Morocco was in Allied hands, and the Vichy-appointed government had thrown in its lot with the Allies. This successful Allied invasion of French North Africa, however, led in the same month to the occupation of Vichy France by the Germans, and of the French island of Corsica by the Italians.

Tripoli fell to Montgomery's advancing armies on January 23, 1943, and the Axis forces retreated into Tunisia, where, pressed towards Cape Bon from the east and the west, they finally capitulated on May 12. A quarter of a million men—more than half of them Germans—were taken prisoner ; 663 escaped by sea or air.

At the end of May, General de Gaulle went to Algiers, and with General Giraud, then High Commissioner of French North Africa, set up the Committee of National Liberation there on June 3. This was recognized by the Allies in August as administering "those French overseas territories which acknowledge its authority," Algiers thus becoming the French capital for the time being.

Invasion of Sicily

On July 10 the Allies invaded Sicily in strength : an entry had been forced into Hitler's "impregnable" fortress of Europe. So rapid was the Allies' progress in Sicily that a government crisis was precipitated in Italy. Mussolini appealed to Hitler, but, finding him unwilling to help to defend the whole country, Mussolini called together the Fascist Grand Council—which had not met since December 1939—and put before it Hitler's suggestion that the country south of the river Po should be abandoned.

The Fascist Council's opposition to this proposal was bitter; Mussolini resigned and was imprisoned but was presently rescued by the Germans. The king appointed Marshal Badoglio, conqueror of Abyssinia, as military governor of the country. The Fascist Party

EIGHTH ARMY OCCUPIES CATANIA. After nearly three weeks of savage fighting, infantry of the Eighth Army entered the port of Catania in Sicily at 8.30 a.m. on August 5, 1943. Here the first British patrol penetrates to the centre of the city.

and the Fascist Grand Council were dissolved on July 28, and Fascism was officially abolished on July 29, 1943.

The Allies, meantime, pressed on with their campaign. In 39 days Sicily was cleared of the Germans—six weeks less than the Allied commanders had anticipated—and on September 3 the Allies crossed the Straits of Messina and landed on the mainland of Europe, in Calabria. The same day Italy surrendered unconditionally and signed an armistice, kept secret however until it came into force on the 9th, on which day the Allies made a further landing on the shores of the Gulf of Salerno, a little to the south of Naples ; and on September 15 the Germans began to retreat.

SURRENDER OF THE ITALIAN FLEET. Following Italy's surrender to the Allies on September 3, 1943, the Italian fleet sailed for Malta. Here Admiral Romeo Oliva is being received by Commodore R. M. Dick, Admiral Cunningham's Chief of Staff, as he steps ashore on September 10 to tender his surrender.

The Italian fleet, surrendered under the armistice, reached Malta on the 10th. Taranto fell without a blow on the 9th, Brindisi on the 11th ; and the whole Otranto peninsula was occupied with little opposition. Through the captured ports strong reinforcements reached the Allied forces advancing from Calabria towards those at Salerno. On the 17th the two armies met at Agropoli and began to advance along the whole width of Italy through difficult mountainous country, and against a stubborn German defence. Naples was occupied on October 1, and on October 13 Italy declared war on Germany. By the end of the year the Allied line ran from the mouth of the Garigliano on the west to a little north of Ortona on the east.

Corsica was liberated on October 4, twenty days after the first landings of French troops. But Rhodes, chief of the Dodecanese, was lost, the Italian commander, Admiral Campione, a Fascist, surrendering to the Germans on the day Italy surrendered to the Allies, although he had 40,000 Italian troops to 9,000 Germans. As a result of the loss of Rhodes, Cos was lost on October 9, and Leros on November 16, while Samos was evacuated a few days later, and the Germans were left in control of the Aegean.

Partisans in Yugoslavia and Greece, assisted by British liaison officers and equipment, became very active ; but they were hampered by internal differences which in both countries brought the insurgents to fratricidal strife. The most influential Yugoslav leader, Marshal Tito (as Josip Broz began to call himself), was in December raised to the status of a full Allied commander.

Allied Air Attacks

The establishment of the Allies on the mainland of Europe gave them a number of additional airfields, from which bombing operations conducted from Great Britain were supplemented. The railway at Bolzano, at the southern end of the Brenner Pass, suffered several heavy attacks ; the marshalling yards of Innsbruck were bombed ; so were the manufacturing town of Wiener Neustadt and the neighbouring centres of Ebenfurth and Friedburg. Sofia, capital of Bulgaria, was heavily raided by day ; targets on the Dalmatian coast and industrial towns in northern Italy were constantly attacked.

In December 1939 the 8th Pan-American conference, sitting at Lima, Peru, issued a declaration re-affirming the solidarity of the western hemisphere and the intention of the

CROSSING OF THE VOLTURNO. During the night of October 12–13, 1943, the Allied 5th Army attacked across the strongly-held Volturno River, north of Naples : here British troops cross a pontoon bridge constructed by American engineers.

21 republics to collaborate against all foreign intervention. The possibility of such intervention grew in 1940 with the German conquest of the Netherlands and France, both of which countries had colonies on the American mainland. The U.S. Senate voted unanimously against permitting the transfer of any territory in the Americas from one non-American power to another, and a conference of American foreign ministers at Havana in July 1940 agreed that should Germany attempt to seize any of the conquered countries' colonies, an American republic feeling itself threatened was entitled to take over the colony by force.

The political situation on the American continent was complicated by the presence of large numbers of citizens of German, Italian, and Japanese birth or descent, a proportion of whom sympathised with the Axis ; and also by the fact that to many Latin-Americans "Yankee" economic domination was as disagreeable as any other. But all the republics assembled in conference at Rio de Janeiro in January 1942 passed a resolution recommending each country to break off diplomatic relations with Japan, Germany, and Italy. Ten of the republics already at war were among the 26 nations which had agreed to support the Atlantic Charter. Only Argentina and Chile failed to act on the Rio de Janeiro recommendation. Chile, however, broke off diplomatic relations at the beginning of 1943 ; and Mexico, Brazil, and Bolivia declared war during 1942 and 1943.

LESSON 32

Unconditional Surrender of Germany and Japan

SLOWLY the Allied armies fought their way up the Italian peninsula. They crossed the Garigliano river on the night of January 16–17, 1944. A new landing at Anzio, behind the enemy's lines, on January 22 turned out a "stranded whale" instead of the "wild cat" of Mr. Churchill's hopes, and helped the Allied advance on Rome only to the extent that it held down German troops which would otherwise have been available for use in the main German defence line, the so-called "Gustav Line." By February 2 the Allies had penetrated into Cassino, pivot of the Gustav line.

But at this point they were stopped, for Cassino, through which runs the only possible road to Rome, was overshadowed by Monte Cassino, crowned by the ancient abbey that cradled the Benedictine order. In an effort to overcome this formidable obstacle the Allies with reluctance pounded the abbey to rubble on the 15th. But the Germans defending the height found shelter in the complicated network of tunnels which ran below the building, whose ruins served them admirably for defence and reconnaissance.

"HANGMAN'S HILL," CASSINO. Scene of devastation under Monte Cassino, where desperate German defence held up the Allied advance in Italy from February 2 to May 18, 1944.

Capture of Rome

For three months the Allied armies lay at this point, until on May 11 a combined assault of the 5th and 8th Armies—the latter moved secretly over from the Adriatic coast—carried Monte Cassino on the 18th ; a link with the troops of the Anzio beachhead was made at Borga Grappa on May 25. Steady advance through the Alban Hills against strong resistance brought the Allies on June 4 into undamaged Rome, from which the Germans had retreated to take up new defensive positions, the "Gothic Line," between Pisa and Rimini. (General Alexander, commander-in-chief of Allied forces in Italy, was promoted Field Marshal in recognition of his, the first Allied, capture of a capital city in Nazi-occupied Europe.)

On June 6, the most important D-Day (i.e. day of invasion) of the European war, British and American armies landed in Normandy. This tremendous operation, planned during more than two-and-a-half years, was preceded by bombing attacks on enemy communications, industry, and centres of oil production. The first landings were made by parachute and glider-borne troops transported across the

ALLIED LANDINGS IN NORMANDY. Five "beaches" were occupied by the Allies on June 6, 1944, between the north-east tip of the Cotentin peninsula and the mouth of the river Odon on which Caen stands. From east to west they were named Utah, Omaha, Gold (round Arromanches), Juno, and Sword. This picture, taken on June 7, shows landing craft coming into one of the British beaches.

Channel by an air armada that stretched for 200 miles. More than 5,000 ships carried and protected the seaborne forces, who began to go ashore at 6.30 a.m. on June 6 on the Normandy coast between Caen on the east and the east coast of the Cotentin Peninsula on the west. The operation, timed originally to take place early in May, had been put off until June 5, when it was again postponed for 24 hours on account of bad weather. The weather forecast for June 6 was not good, but the Supreme Commander of the Allied Expeditionary Force, General Dwight D. Eisenhower, decided that the risk should be taken. It seems likely that, though poor weather increased difficulties of transport and landing, it put the enemy off his guard. In any event, the first landings, under the command of General Montgomery, were made with surprisingly low casualties, both in men and ships. Only at one point did the Allies meet serious resistance, and that was on a beach in the American (west) sector where the Germans happened to be staging an anti-invasion exercise. Even when the Allied forces were ashore in considerable strength, the Germans remained convinced that the Normandy landing was a feint to cover the real attempt they expected at one or other of the ports farther east, and they failed to move their troops and armour immediately to the actual danger zone.

Mulberry Harbour

To assist in the Allied build-up, two artificial ports (code name, Operation Mulberry) had been designed and prefabricated and were towed across the Channel in sections. Parts of Mulberry A, intended for the Americans, were wrecked in the worst storms for 40 years. Fortunately the Americans rapidly cleared the Cotentin Peninsula, capturing Cherbourg on June 27. Mulberry B, at Arromanches in the British sector, rode out the gales.

Battle of the Falaise Gap

The Americans, having captured Cherbourg, turned south and, assisted by the French forces of resistance (recognized by the Supreme Commander as a fighting unit, and renamed the French Forces of the Interior), cleared Brittany, except for the strongly fortified ports

BRITISH CAPTURE CAEN. The hub of twelve major roads, the Normandy town of Caen was fiercely defended by the Germans in tank battles lasting from June 25 to July 9, 1944.

BATTLE OF THE FALAISE GAP. Two lines of British tanks—one moving up into the battle area to relieve the other coming away from it : a photograph taken during the fighting in August 1944 which destroyed the German 7th Army hemmed into a pocket near Falaise, Normandy.

of Brest and Lorient. In the meantime, the British and Canadians held down around Caen (captured July 9) the bulk of the German armour arriving from the east. The American left turned eastward, to meet the British and Canadians just south of Falaise and destroy most of the German 7th Army trapped in the " Falaise gap " by August 22—the first decisive victory of the re-opened western front. The enemy remnants retreated headlong across the almost bridgeless Seine.

Montgomery commanded all Allied ground forces from June 6 to August 1, 1944, and continued to co-ordinate action between his own 21st Army Group (Canadian 1st and British 2nd Armies) and the U.S. 1st and 3rd Armies (12th Army Group), commanded by General Omar Bradley from August 1, until Eisenhower established his headquarters (Supreme Headquarters Allied Expeditionary Force, or SHAEF) in France on September 1.

Liberation of Paris

The American right swept on southeastwards. With them was the French 2nd Armoured Division, which reached Paris on August 24, two days after French patriots in the city, who rose on August 19, had expelled the enemy from its centre. Next day American units entered Paris. The Committee of National Liberation, headed by General de Gaulle, moved from Algiers to Paris; it was recognized by Great Britain, the U.S.A., and Russia on October 23 as the provisional government of France, and as France was liberated the country was transferred to its authority. Belfort fell to the French on November 20, Strasbourg to the Allies on the 24th.

The " July Plot "

During the weeks which led to the liberation of Paris, the Nazi régime weathered an internal attack that had been two years in the planning : a time-bomb placed beforehand in a room in which Hitler was to hold a conference on July 20 went off as arranged. The room used, however, was not in the concrete underground structure anticipated by the conspirators but in a flimsy surface building whose walls gave way under the blast. Hitler was slightly wounded. A ruthless purge followed. Thousands of men and many women who were certainly not cognisant of the plot, but might, if it had succeeded, have been prepared to act under a more liberal government, were executed. Field Marshal von Witzleben and other high-ranking officials deeply implicated in the plot were hanged ; Colonel Count Stauffenburg (who had placed the bomb) and General Olbrecht were shot ; Colonel-General Beck committed suicide. Even Rommel, about whose death (said to have been due to an air attack on his

LECLERC REACHES PARIS. Tanks of the French 2nd Armoured Division entered the city on August 24, 1944. The division's commander, General Jacques Philippe Leclerc, is seen here next morning on the Boulevard Montparnasse.

car) there were doubts, was thought to have been involved.

Heinrich Himmler, chief of the Gestapo, emerged as the effective master of Germany and Commander of the German Home Army.

The U.S. 7th Army (which included French forces that were the nucleus of the French 1st Army formed on September 15) landed in the south of France on August 15 between Nice and Marseilles.

Drive to the Rhine

Marseilles and Toulon were rapidly captured, and Allied forces, assisted by the men of the Maquis (the active French resistance movement), advanced steadily up the Rhône valley, wheeled east round the northern frontier of Switzerland, and on September 11 fell in on the right of the armies advancing from Normandy towards the Rhine.

ACTION AT ARNHEM. The British 1st Airborne Division, dropped west of Arnhem, September 17, 1944, fought for ten days while the British 2nd Army tried in vain to reach them : here is one British parachutist at Oosterbeek.

Battle of Arnhem

British and Canadian forces in the north pushed eastward in the coastal sector. The Pas de Calais was cleared by the beginning of October. Brussels was freed on September 3. Airborne landings in force at Arnhem, Nijmegen, and Eindhoven on September 17 and 18 failed to secure the rapid crossing of the Rhine delta that had been their aim—ground forces were unable to come up in time across the difficult country. Most of Belgium and of the Netherlands south of the Maas was liberated by November 7, though it was not till November 9 that the northern shore of the Scheldt estuary was cleared. The channel was swept, and on November 26 a full convoy of Allied shipping entered the great port of Antwerp. The Americans invaded German soil on September 11 ; Aachen, reduced to rubble after repeated warnings, surrendered unconditionally on October 20

Russians Cross the Russian Frontier

In eastern Europe the Red Army drove the enemy steadily westward, beyond the Dnieper and into the Carpathians. By April 2, 1944, Soviet forces were swarming into Rumania. Odessa was liberated on April 10. A short, sharp campaign beginning on the same day with the recapture of Armiansk (taken on November 1, 1943, and lost again) freed Sevastopol on May 9, and the whole Crimea by May 12. In White Russia the Red Army advanced to cross the borders of 1939 Poland on January 4, 1944 ; while to the north an advance starting on January 15 relieved Leningrad from a siege which had lasted since November 1941, and brought the Soviet forces to Estonia by the beginning of February. The Red Army forced its way through Lithuania, crossing the frontier into East Prussia on October 23, there to meet determined resistance. Riga fell on October 13. Finland, after tentative efforts towards peace in the early part of the year, fought on until cut off from German help. The Finns negotiated an armistice with the Allies on September 19 and the Russians advanced to the northern frontier of Norway. In Rumania, Constanta, Ploesti, and Bukarest fell to the Russians on successive days at the end of August. Rumania sued for peace, and on August 25 re-entered the war on the side of the Allies. The Bulgarians,

FIRST DOWN AT ARNHEM. Men of the 1st Air Landing Brigade, first unit to land on September 17, 1944 ; it was a glider-borne formation consisting of three infantry battalions and a field ambulance.

RUSSIAN GUERILLAS. This body of men and women who had fought as guerillas behind the enemy lines in the Leningrad area during the long German siege of the city (which began on November 11, 1941) march towards Leningrad after its relief by Russian regular forces on January 27, 1944.

isolated from Germany, attempted to bargain, but capitulated when, on September 5, 1944, Russia declared war on Bulgaria. The Germans retreated along the Danube. Their armies of occupation in Yugoslavia and Greece began to withdraw, harassed by Yugoslav partisans led by Marshal Tito. The Russians liberated Belgrade on October 20, and had completely invested Budapest by Christmas Day.

Greek Civil War

When British and Greek regular forces landed in Greece on the night of October 4–5, they found only enemy rearguards. They reached undamaged Athens on October 13. But three years of German occupation following five years of dictatorship had left Greece in an appalling state of dearth and dissension. After prolonged and stormy negotiations, a national all-party Greek government in exile had been formed in Cairo on September 2, 1944, and by the Caserta agreement (September 24) all the Greek guerilla forces placed themselves under General Scobie, Allied G.O.C. in Greece.

The exiled Greek government arrived in Athens on October 18. British military supplies were brought in to relieve the starving people (British troops were put on half rations), and strenuous efforts were made to stabilise the currency. But when in December the Greek government ordered the disbandment of all guerilla forces, the men belonging to the Communist-directed Ellenikos Laikos Apeleutherotikos Stratos refused to surrender their arms, and civil war broke out. E.L.A.S. forces attacked the British naval headquarters, and sharp fighting followed between them and the British. In Athens, unharmed by the Germans, more than 2,000 houses, shops, and factories were destroyed during the fighting, and 15,000 people were rendered homeless. In an effort to settle the situation, Mr. Churchill and the British secretary for foreign affairs, Mr. Eden, flew to Athens on Christmas Day, and called together a conference representative of all shades of Greek political opinion. Its only decision was to appoint Archbishop Damaskinos, a man respected by all, as Regent. Organized fighting ceased in Athens and the Piraeus on January 5, 1945 ; but it was more than three years before fighting in Greece was ended along its frontiers with Communist Albania, Yugoslavia, and Bulgaria, which countries gave the Greek rebels aid and shelter until after Yugoslavia was expelled from the " Cominform," successor organization to the " Comintern " in June 1948.

Russia and Poland

When the Russians were about to enter Poland, the Soviet government proposed that Poland should be given the eastern frontier assigned to it in 1919 (*see* Lesson 28), and in compensation for the territory (gained by the treaty of Riga, 1921) which it would lose should accept part of East Prussia and other German lands. The Polish government exiled in London refused this proposal. In July 1944 the Russians agreed with a National Liberation Committee they had set up in Lublin that it should administer liberated Polish territory. On December 31 this committee declared itself the provisional government of Poland. The U.S.S.R. recognized it as such, but not Great Britain or the United States, both of which continued to recognize the Polish government in London.

The Yalta Conference

A conference between the United Kingdom, the United States, and Russia held at Yalta in the Crimea during February 1945 agreed that the provisional government actually functioning in Poland should be broadened by the inclusion of democratic leaders from within Poland and from abroad, that Poland's eastern frontier should follow the so-called " Curzon " line, and that the country should receive large accessions of territory in the north and west. At this conference it was also decided to invite France to take a zone of occupation in Germany ; and to call a conference at San Francisco on April 25, 1945, to prepare the charter of an organization for world peace. In addition, secret agreements were made by which the Russians promised to declare war on Japan not later than three months after fighting ended in Europe, in return for which Russia was to recover south Sakhalin and the Kurile Islands (lost in 1905) ; the United States was to occupy the Pacific islands (formerly German) mandated to Japan after the First World War.

MEETING AT YALTA. Mr. Churchill, President Roosevelt, and Marshal Stalin met in February 1945 to concert plans for occupation of Germany and for the San Francisco Conference. Behind the " Big Three " stand Mr. Eden, Mr. Stettinius, Sir Alexander Cadogan, Mr. Molotov, Mr. Averill Harriman.

Yalta was the last inter-Allied conference attended by President F. D. Roosevelt. Re-elected in 1944, he died suddenly on April 12, 1945, less than four months after his fourth term of office began on January 20. He was succeeded by the vice-president, Harry S. Truman.

The Polish government in London refused to recognize the decisions with regard to Poland made at Yalta. On April 6 the London government announced that on March 27 and 28 fifteen Polish leaders had presented themselves, at the invitation of the Soviet commander, to General Ivanov, representing the High Command of the 1st White Russian Front, since when nothing had been heard of them. Nothing more was heard until on May 3, at San Francisco, Mr. Molotov informed Mr. Eden and Mr. Stettinius, American secretary of state, that they had been arrested. This information electrified the conference at which, on April 25, representatives of the 42 United Nations had assembled and were in process of drawing up the charter of the proposed organization for preserving world peace (ratified first by the United States Senate on July 28). Inter-Allied talks on the Polish question were suspended ; of the arrested Poles, accused of sabotage against Soviet forces in Poland (a charge to which some pleaded guilty), all but three, who were acquitted, were condemned to various terms of captivity. A new Polish government, including members of the London exiled government, was formed, and was recognized by Great Britain and the United States on July 5.

German Surrender in Italy

Following the capture of Rome, the Allied armies in Italy conquered Tuscany. After blowing up all the bridges across the Arno in Florence except the narrow Ponte Vecchio, the Germans evacuated that city on August 11, 1944, and the Allies entered it next day. Then came eight months of patrolling and small, hard-won local gains in difficult fighting through fifty miles of mountainous country. A new offensive, launched on April 9, 1945, carried the Allies into the valley of the Po by the 20th. Bologna was liberated on April 21 ; Spezia, Ferrara, and Modena on the 24th ; Parma, Mantua, and Reggio on the 25th. In Verona, entered by the Allies on the 26th, Italian patriots had already taken control. Genoa and Milan were also in their hands. The Allies entered Genoa, Piacenza, and Bergamo on the 27th, and on the same day French troops crossed the Franco-Italian border and took Ventimiglia and Bordighera. Mussolini was captured by partisans at Dongo (Lake Como) on the 28th, and was summarily shot with other

FLORENCE, 1944. The Germans declared Florence an open city, July 1, 1944, but did not evacuate the north of it until August 11, although the Allies were in possession of the southern suburbs by August 5. Before leaving, the Germans blew up all the bridges except the Ponte Vecchio (right).

Fascist leaders. His body was ignominiously displayed, hung up by the feet, in a Milan square.

On April 29 the Germans in Italy surrendered unconditionally to Field-Marshal Sir Harold Alexander. The Allies entered Venice and Milan that same day, Turin on the 30th. New Zealand forces crossed the Isonzo on May 1, linked up with Marshal Tito's Yugoslav troops, and entered Trieste on May 3. Stiff resistance continued in the Lake Garda area; but on May 5, 1945, troops of the Allied 5th Army from Italy met troops of the U.S. 7th Army from Austria in the Brenner Pass; the campaign in Italy was over.

Ardennes Counter-Offensive

The comparative quiet of the western front was shattered on December 16, 1944, by a last desperate German counter-offensive in the Ardennes region. Rundstedt, achieving tactical surprise, drove a deep wedge into the Allied line, cutting off the U.S. 1st and 9th Armies from their headquarters in Luxemburg.

The 1st and 9th Armies were transferred for the time being to Field-Marshal Montgomery's command. Steady pressure inwards on the German wedge (which just failed to reach Liége and the Meuse) by Montgomery from the north-west and by the U.S. 3rd Army from the south-west wiped out the German salient, and by January 31, 1945, had restored the Allied line to that of mid-December. A general loosening of enemy resistance followed. By February 9 the French 1st Army had liberated Alsace, and French and American troops were standing along the Rhine. The last Germans were driven out of Luxemburg on February 22. By March 2 München-Gladbach and Krefeldt had been captured; the German 15th Army was in disorganized retreat across the Rhine; Trier, key to the rugged Moselle valley, was in Allied hands, and Venlo and Roermond in the Netherlands had been liberated. Terrific air bombing attacks were made. On February 1 the Russians were 50 miles from Berlin. The city, crowded with refugees, received over 2,500 tons on February 3; in three assaults on February 13 and 14, 10,000 tons were dropped on Dresden (then 70 miles from the Soviet front, and also filled with refugees fleeing before the Russian armies): every building in the centre of the city was destroyed, an estimated 45,000 were killed (more than 21,000 dead were recovered from the ruins 18 months later). On February 20, Nuremberg received 11,000 high explosive and 300,000 incendiary bombs; Cologne was twice bombed on March 2; Chemnitz, Cottbus, Magdeburg were bombed in direct support of the Red Army; and there were many other assaults.

Cologne was captured on March 6. On

ARDENNES COUNTER-OFFENSIVE. In December 1944 the Germans attacked westward, advancing from the German frontier to within four miles of the River Meuse before they were held and then pressed back by British and U.S. forces commanded by Field-Marshal Montgomery. These British tanks are in a wood near Laroche, recaptured January 11, 1945.

March 8 a patrol of the U.S. 1st Army established a bridge-head across the Rhine at Remagen, reached by an advanced patrol at 3.50 p.m., ten minutes before the Ludendorff railway bridge was due to be blown up. Bonn was captured on the 9th, Coblenz on the 18th. German resistance west of the Rhine collapsed on March 20. The over-running of the Saar basin was completed the same day.

Across the Rhine

Then on March 24 came an Allied communiqué: "Allied forces to-day crossed the Rhine on a wide front north of the Ruhr." It was the largest single operation since the landings in Normandy. Army, Navy, and Air Force co-operated. All organized resistance to the 21st Army Group ceased on March 27, except on its extreme left where the enemy fought to keep open the routes from the Netherlands.

The Netherlands

The Allies had hoped to free the Netherlands without making a direct attack, but the Germans did not withdraw, and conditions there had become desperate. The Allies, anticipating a quick break-through, had allowed the Dutch government on September 17, 1944 (the day of the first airborne landings at Arnhem), to call on railwaymen to strike. The men had struck, and despite every threat had held out.

German Reprisals Against Dutch

But as a reprisal the Germans had refused to bring any food into the country—indeed, they removed the small reserves which had been built up in the towns by the Dutch authorities. During the winter of 1944–45 there was no fuel in the towns of the provinces of North and South Holland, and the daily rations, 460 calories daily at the end of December, dropped to 320 calories daily in March—a quarter of the minimum considered necessary for normal human beings. The Germans made great efforts to round up the men for work in Germany, by threats and by offers of a warm meal in a warm room, but hundreds of thousands eluded the call-up. It was feared that the whole nation would be dead or dying of starvation unless the country were liberated by May 1, and it was therefore decided at the beginning of April to launch a large-scale Allied attack.

Enschede, reduced to rubble, was taken on April 2. The British crossed the Yssel on April 13, and cleared Arnhem next day. Zutphen fell to the Canadians on April 7, and two battalions of French parachutists, dropped in the Groningen-Zwolle area on the night of April 7–8, created wild confusion among the enemy. Helped by the Dutch resistance movement, they held out until relieved by Canadians and Poles a week later. Canadians reached the North Sea at Ternaard on the 15th, the Ysselmeer (as the Zuyder Zee was called after the great barrage cutting it off from the North Sea was completed in 1933) on the 17th, when they were joined by British troops who had just taken Ede. On the same day the enemy began the wholesale flooding of the rich agricultural lands of North Holland by opening the sluice gates and blowing great breaches in the dykes holding back the Ysselmeer. The ever-present fear of all Dutchmen that the enemy

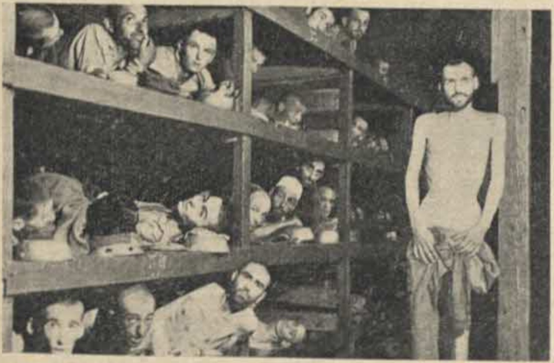
ALONG THE RHINE. The Ludendorff railway bridge at Remagen, captured March 8, 1945, by U.S. Lieut. Karl Timmerman (1922–51), acting on his own initiative : it was the only Rhine bridge captured intact, and this was the first Allied crossing of the Rhine. Above, troops of the Canadian 1st Army moving in "buffaloes," December 1944, over flooded land near Nijmegen.

THE END OF A DREAM. When the U.S. 7th Army captured Berchtesgaden, Hitler's retreat in the Bavarian Alps, on May 4, 1945, they found its ruins still smoking from an R.A.F. raid on April 25.

might breach the barrage between the North Sea and the Ysselmeer was, happily, not realized.

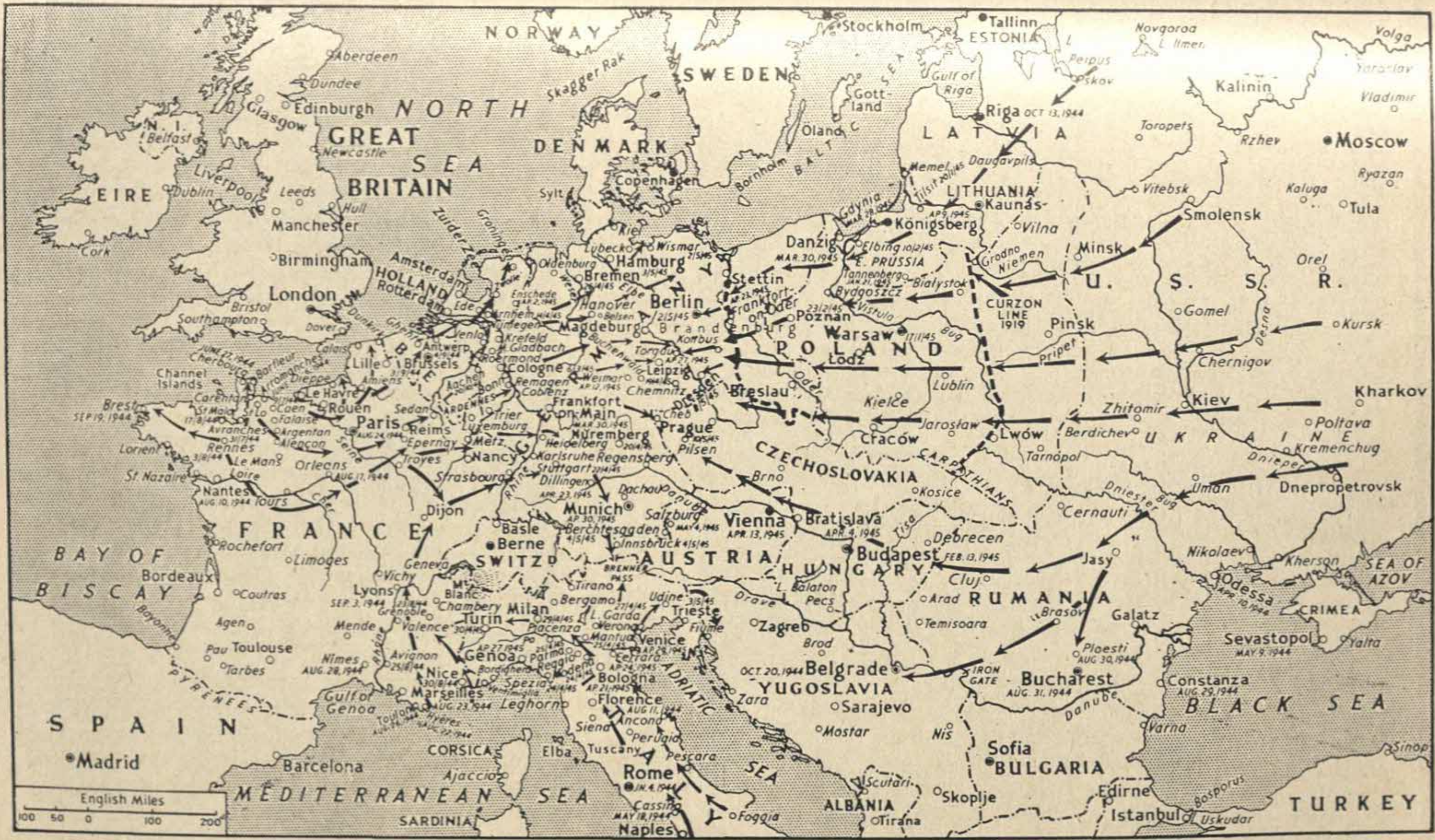
Heidelberg, virtually intact, and Frankfort-on-Main, with hardly a house undamaged, fell on March 30. The French 1st Army crossed the Rhine on March 31, to capture Karlsruhe on April 3. American forces encircled the Ruhr on April 3, cutting off a German army of 100,000. They cleared it by April 20. The locking up of one German army in the Netherlands and another in the Ruhr enabled the 21st Army Group to advance across the North German plain without serious resistance: by April 21 it was in control of 35 miles of the Elbe. The Americans crossed the Elbe farther south on April 12, and captured Weimar; nearby they over-ran Buchenwald camp where over 50,000 political prisoners had perished—German, Czech, French, Polish, Dutch, and other nationalities. In the south, Leipzig fell on April 19, Nuremberg on the 20th. The French captured Stuttgart on the 22nd, Mulheim on the 23rd. American troops were pouring across the Danube at Dillingen in Bavaria on the 23rd. The French reached the Swiss frontier at Basle on April 25. On the 26th Bremen surrendered to the British, and U.S. forces captured Eger in Czechoslovakia. Firm contact between General Eisenhower's armies and Soviet forces advancing from the east was made at Torgau on the Elbe on April 25.

EAST AND WEST MEET ON THE ELBE. On April 25, 1945, patrols of the 273rd Regiment, 69th Division, V Corps of the U.S. 1st Army met elements of the Russian 58th Guards Division on the Elbe, near Torgau, some 30 miles north-east of Leipzig.

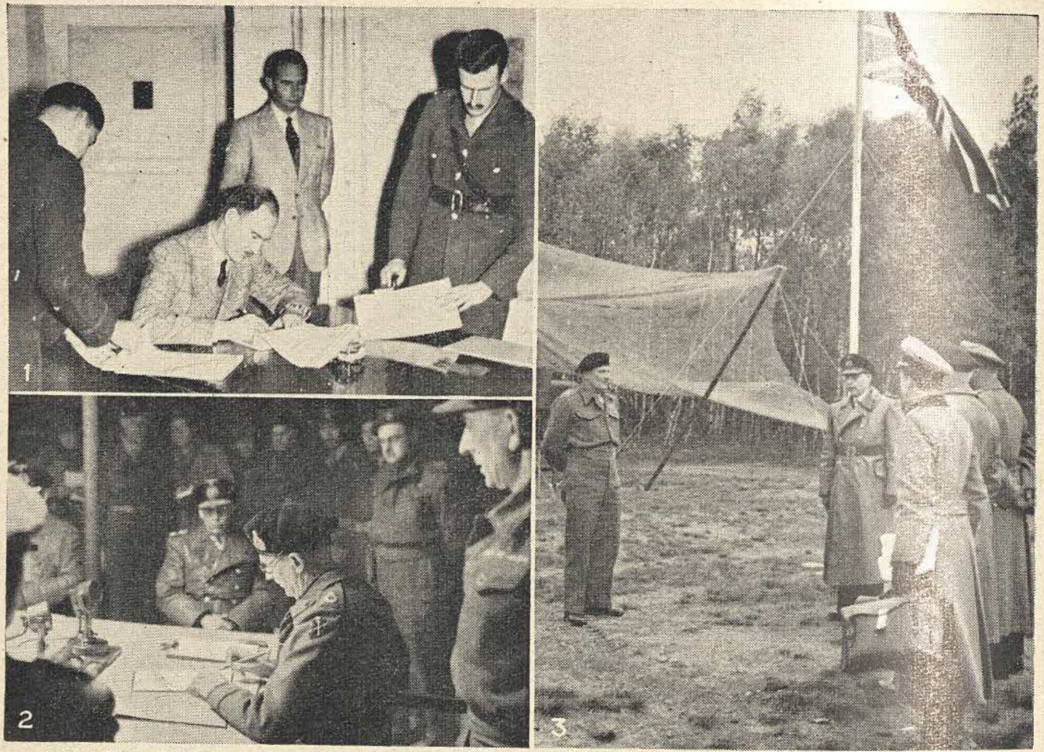


BUCHENWALD. A corner of this concentration camp near Weimar when it was overrun by the U.S. 3rd Army on April 12, 1945. The 21,000 prisoners found in the camp were near death from starvation.

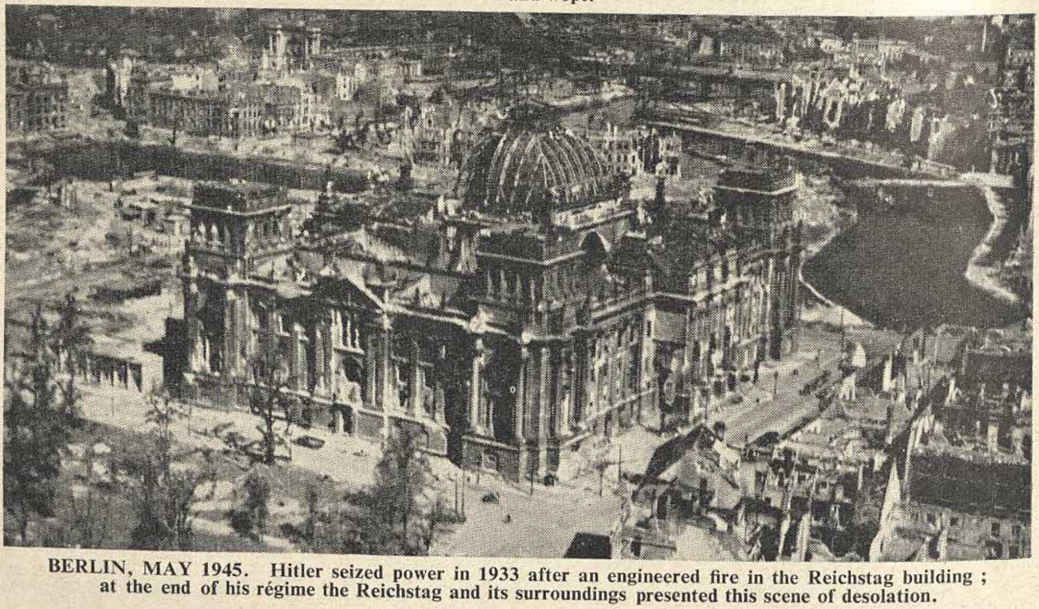
Early in January 1945 a great new Soviet offensive began in Poland and White Russia. Warsaw was liberated after five years and four months of German occupation, on January 17. By the 19th, Soviet forces had liberated every large Polish town except Poznan and were pushing on into East Prussia. Tilsit fell on January 20, Tannenberg next day. Lithuania was liberated by the 28th; German Pomerania, Brandenburg, and West Prussia were invaded on the 29th. The Oder was forced on February 6, in a blinding snowstorm. Elbing fell on the 10th, Poznan on the 23rd after holding out desperately since January 26. Küstrin (Kostrzyn) was captured on March 12 after a week of violent fighting, Gdynia fell on the 28th, Danzig (Gdansk) on the 30th, Königsberg (Kaliningrad) on April 9. Frankfort-on-Oder was captured on the 23rd, and on the same day the Russians broke into Berlin from north, east, and



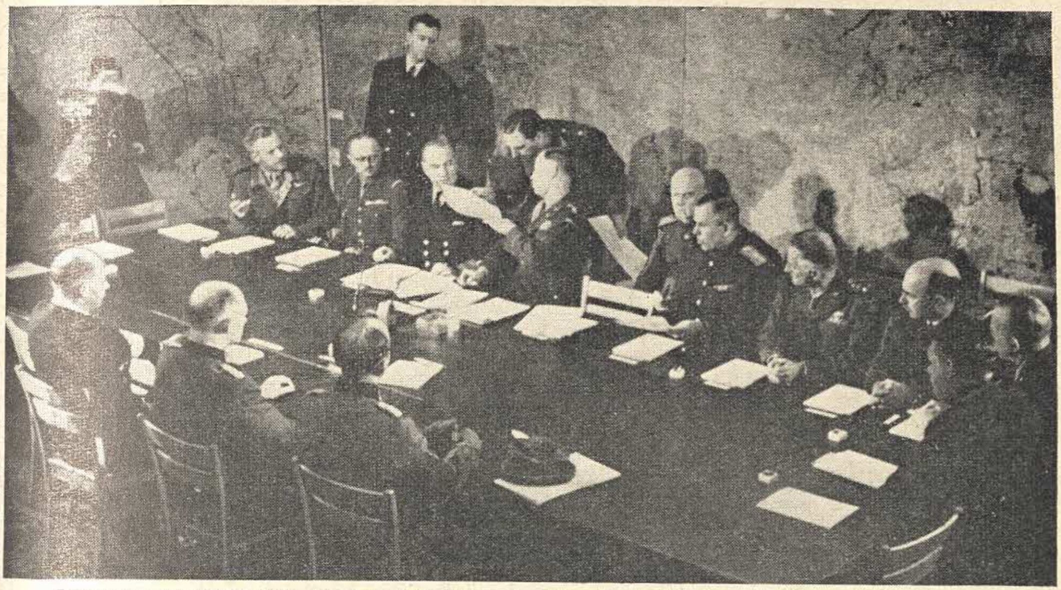
LIBERATION OF EUROPE FROM THE NAZIS. Map indicating the general lines of advance during June 1944 to May 1945 of the various Allied armies advancing from the West and from the East eventually to overwhelm and occupy the whole of Germany. In so huge a campaign it is possible to show only general movements, the arrows giving only a rough indication of often very complex local operations. The dates shown are those on which the cities and towns named were taken from the Germans.



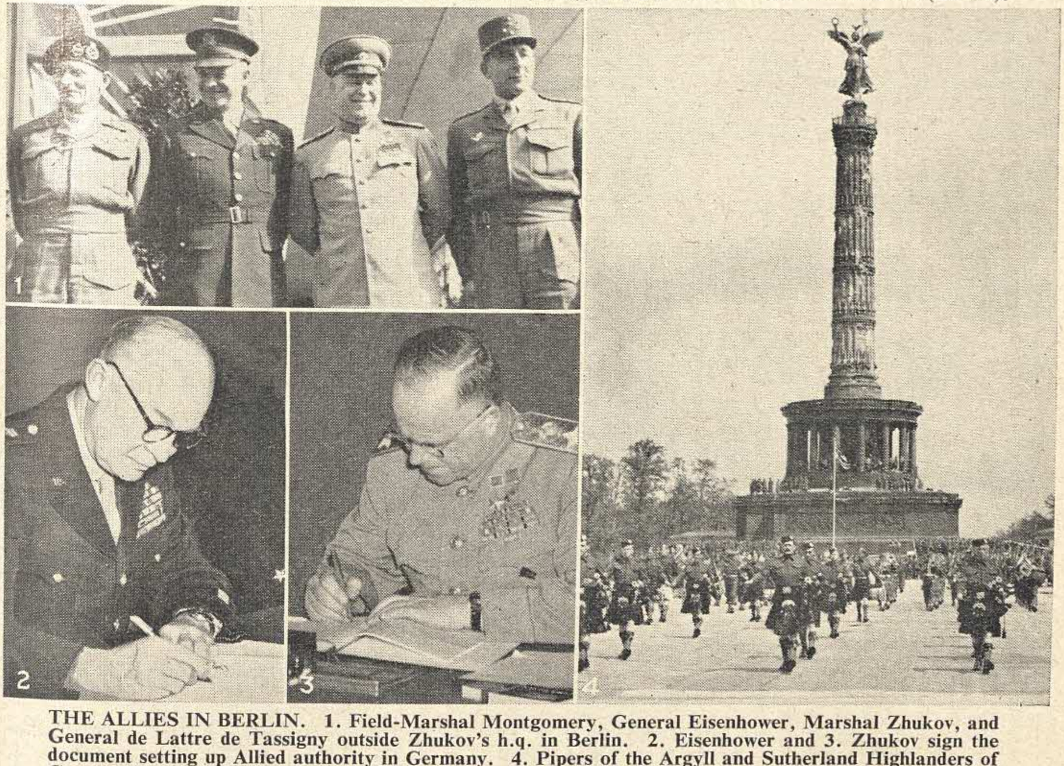
THE END IN ITALY AND IN N.W. EUROPE. 1. Col.-General Heinrich von Vlietinghoff-Schiel's representative signs at Caserta, April 29, 1945, the surrender to Field-Marshal Alexander of Germans in Italy and W. Austria : the first act of surrender. 2. Field-Marshal Montgomery countersigns the field surrender, May 2, 1945, on Lüneburg Heath of all German forces in N.W. Europe following the arrival (3) at his h.q. of General-Admiral von Friedeburg (back to flagstaff) to ask for an armistice. When Montgomery showed on his operational map the plight of the German armies, von Friedeburg broke down and wept.



BERLIN, MAY 1945. Hitler seized power in 1933 after an engineered fire in the Reichstag building ; at the end of his régime the Reichstag and its surroundings presented this scene of desolation.



GERMAN SURRENDER AT RHEIMS, MAY 7, 1945. In the Rheims schoolhouse that was General Eisenhower's headquarters the German representatives (left) General-Admiral Hans Georg von Friedeburg, navy c.-in-c., Colonel-General Gustav Jodl, army chief of staff, and Major Wilhelm Oxenius, A.D.C. to Jodl, face Lt.-General Sir Frederick Morgan (British), General François Savez (French), Admiral Sir Harold Burrough (British), Lt.-General W. Bedell Smith (U.S.), Major-General Ivan Souslaparov (Russian), General Carl Spaatz (U.S.), and Air Marshal Sir James Robb (British).



THE ALLIES IN BERLIN. 1. Field-Marshal Montgomery, General Eisenhower, Marshal Zhukov, and General de Lattre de Tassigny outside Zhukov's h.q. in Berlin. 2. Eisenhower and 3. Zhukov sign the document setting up Allied authority in Germany. 4. Pipers of the Argyll and Sutherland Highlanders of Canada lead the British forces as they march past the 1870 Victory Column in the Tiergarten.

south. To the south, the Red Army cleared Budapest on February 13 after a siege lasting seven weeks. Bratislava (Slovakia) was captured on April 4 ; Vienna, reached on the 6th, fell on the 13th.

Fall of Berlin

The heavy fighting in Berlin came to an end on May 2. Hitler was said by a German communiqué to have "fallen in battle at the head of the heroic defenders," but Dr. Hans Fritsche, Nazi radio commentator, told his Russian captors that Hitler, Goebbels, and the newly appointed Chief of Staff, General Krebs, had committed suicide. Goebbels with his wife and family was found dead in the cellars of the Chancellery, where Hitler and a few of his followers had remained to the last.

The Americans occupied Munich on April 30, and freed Dachau, most notorious of concentration camps, containing 32,000 political prisoners. The British 2nd Army reached the Baltic at Wismar on May 2 ; Hamburg and Oldenburg surrendered on the 3rd ; the Americans captured Berchtesgaden, Salzburg, and Innsbruck in Austria on the 4th and on the Brenner Pass on May 5 met men of the Allied 5th Army which had fought its way through Italy.

Germany Surrenders Unconditionally

By May 5 the whole of Germany except a small area of less than 4,000 square miles was in Allied occupation. The Red Flag was flying in Berlin, the Union Jack in Hamburg, the Stars and Stripes in Munich and Nuremberg. On that day at 8 a.m. British Double Summer Time, the unconditional surrender of all enemy forces in the Netherlands, north-west Germany, and Denmark, made to Field-Marshal Montgomery and the 21st Army Group on May 4, took effect. At 2.41 a.m. on May 7 the Germans signed an unconditional surrender at General Eisenhower's headquarters in Rheims (ratified in Berlin at 00.16 on the 9th). On the 8th the Germans in Norway capitulated.

ALLIES IN ACTION IN BURMA. Three-inch mortar shells being poured into Meiktila, a centre of road and rail communications lying 80 miles south of Mandalay. It was captured on February 28, 1945, by the 17th Indian Division.

Dresden did not fall to the Russians until May 8 ; Prague was finally liberated on the 10th. The fighting in Europe was over.

Assam Invaded

In the Far East, Japanese forces gained much new ground in China during 1944, completing a north-south corridor from Manchuria to French Indo-China (in Japanese occupation since 1940), and advancing westwards towards Chungking. Though they did not reach Generalissimo Chiang Kai-shek's capital they forced the United States Air Forces in November to evacuate their bases at Kweilin, Liuchow, and Nanning in Kwangsi province. From Burma the Japanese launched an invasion of Assam on March 17, 1944, but they penetrated only 50 miles into India, and by August 25 had been pushed back over the frontier.

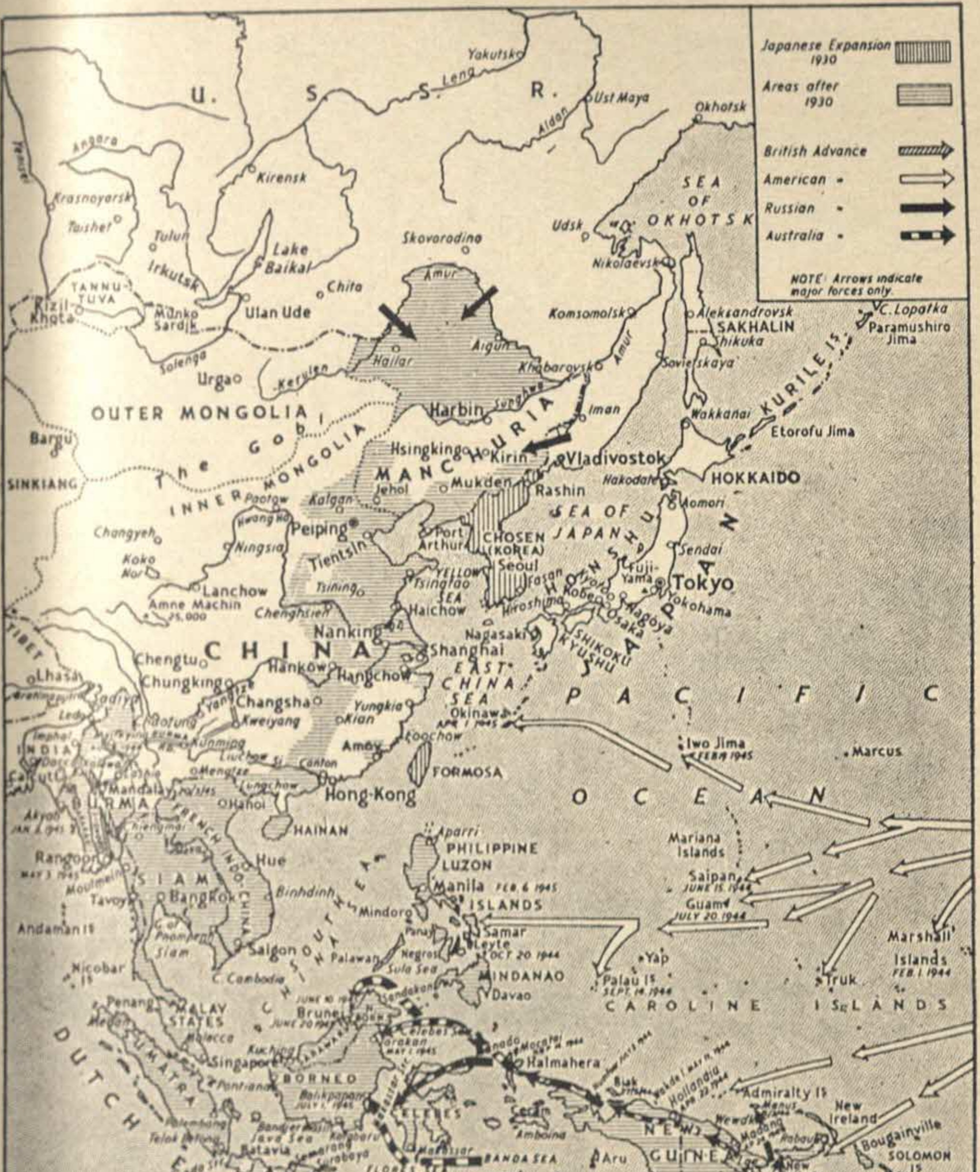
Allied Advance in Burma

General Stilwell, continuing his advance, captured Myitkyina airfields on May 17, the town of Myitkyina only on August 4 after a two-and-a-half months siege. He completed the conquest of his proposed route, and the Ledo Road, on January 23, 1945, when at Mongyu he met Chinese troops advancing into Burma from China. On the Arakan coast, where some of the bloodiest fighting of the Burma war occurred, British forces recaptured Akyab on January 3, 1945. A British force which began to advance in 1944 from India down the Chindwin valley recaptured Mandalay on March 20, 1945. Landings from the sea on both sides of Rangoon river on May 2 brought the British into Rangoon city next day and ended Japanese power in Burma.

Allied Victories in the Pacific

All New Britain except the Gazelle Peninsula (on which lay the neutralised base of Rabaul) was in Allied hands by April 11, 1944 ; and by the end of May the Allies had reoccupied most of the north coast of New Guinea. On February 29 came the first of a series of Allied landings in the Admiralty Islands. The Americans landed in the Marshall Islands on February 1. The strong base of Truk in the Carolines was by-passed, though it suffered very heavy naval and air attacks. Saipan in the Marianas, invaded on June 15, was fully occupied by July 9. Guam (Marianas), in Japanese hands since December 9, 1941, was reconquered between July 20 and August 10, 1944.

The Americans recovered control of Leyte in the Philippines between October 20 and December 25, 1944, of Luzon between January 9



COURSE OF THE PACIFIC WAR. Covering an immense area of Asia and the Pacific, some 5,000 miles W. to E. and 7,500 miles N. to S., this map indicates the extent of Japanese aggression from 1930 to 1942 and the general lines of Allied military advances (other than naval) during 1942–45.

and February 16, 1945 ; the fall of Manila, capital of the Philippines, on February 6, marked the end of one great stage in the Pacific struggle. By April 22 resistance in the Philippine archipelago was confined to Mindanao and the mountains of northern Luzon.

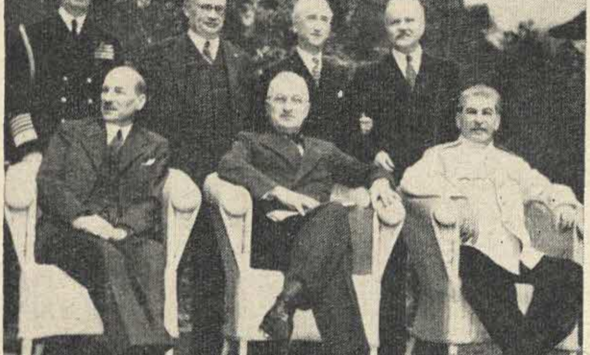
Australians landed in strength on Tarakan, off Netherlands Borneo, on May 1, 1945, in Sarawak on June 20, and at Balikpapan on July 1. Preparations were going forward in India for an invasion from the sea by British forces of Japanese-occupied Malaya.

Meanwhile the Allied advance was approaching Japan, and resistance was becoming desperate. U.S. Marines landed on Iwo Jima in the Volcano Islands on February 19, 1945, meeting light initial opposition ; but as they advanced inland the heaviest fighting to that date in the Pacific developed. When organized resistance ceased on March 16, of a force of some 50,000 U.S. Marines engaged, 4,189 had been killed, 15,308 wounded, and 441 were missing. Japanese casualties, nearly all killed, were 21,000.

Landings on Okinawa

Heavy naval and air bombardment preceded landings on April 1 in very great strength on Okinawa in the Riukiu Islands—part of the Japanese homeland ; resistance did not end until June 21, by which time Japanese dead numbering 98,654 had been counted.

Through these months Japan had lost thousands of aircraft and a very large proportion of her merchant and naval shipping in Allied air and naval attacks ranging from Hollandia in Dutch New Guinea to the China Sea, from Sumatra and Singapore to Japan itself. Tokyo, bombed for the second time in the war on November 24, 1944—this time by Superfortresses based on Saipan in the Marianas—had 27 of its 65 square miles of industrial districts reduced to ashes by April 16, 1945. Air attack on war industry in Japan and in Manchuria grew in weight and frequency.



NEW "BIG THREE" AT POTSDAM. The Allied system of government of Germany was laid down at the Potsdam Conference, July–August 1945. Seated are Mr. Attlee, President Truman, and Marshal Stalin.

On July 14, 1945, began an intensive Allied naval and air bombardment of Honshu, chief island of Japan. The only opposition came from the Kamikaze (suicide) corps, first encountered in October 1944, during violent sea-air battles off the Philippines.

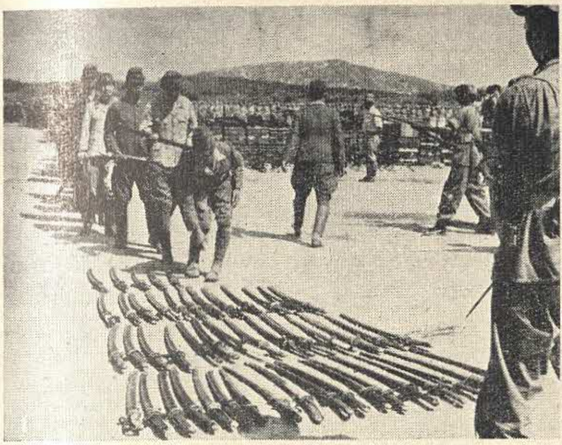
Potsdam Meeting

At Potsdam Winston S. Churchill (later replaced by C. R. Attlee), prime minister of the United Kingdom, President Truman of the United States, and Marshal Stalin of the U.S.S.R. met on July 17, 1945, to concert their policy towards occupied Germany. Stalin, not yet at war with Japan, had brought a tentative Japanese peace offer to Berlin. On the first day of the conference news reached Mr. Truman and Mr. Churchill that an experimental atomic bomb had been successfully exploded in the U.S.A. Stalin was told that the U.S.A. and the U.K. had an entirely new and extraordinarily powerful bomb ; and on July 26 an ultimatum went in the name of the United Kingdom, the United States, and China, offering Japan unconditional surrender or "prompt and utter destruction."

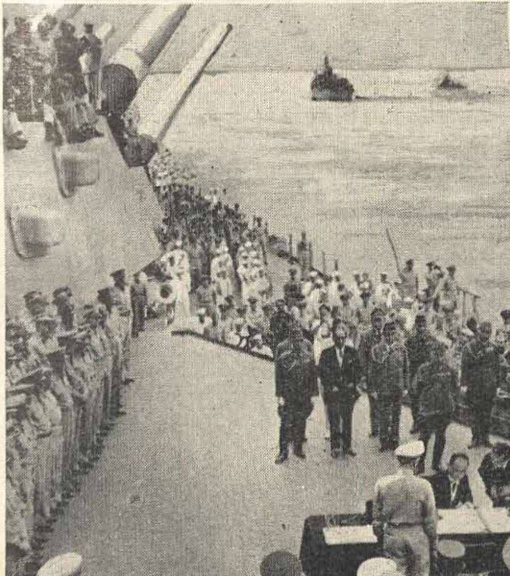
On July 27, U.S. bombers dropped leaflets on eleven Japanese cities warning them they would be destroyed from the air. Five of the eleven were heavily attacked on August 1. On August 6 a solitary U.S. aircraft dropped an atomic bomb over Hiroshima. It exploded 1,000 feet above the centre of the city. All buildings within 10 square miles were wrecked ; 78,150 were killed, 58,869 were injured. The Allies dropped a second atomic bomb, on August 9, over Nagasaki ; it killed 73,864, injured 76,796. On August 14 Japan surrendered unconditionally. Military operations in the Second World War were at an end.

Japan Surrenders

The main instrument of surrender by Japan to the United States and Great Britain was signed on board the U.S.S. *Missouri* in Tokyo Bay on September 2, 1945, and the orderly Allied occupation of the Japanese mainland began at once. The Japanese surrender to Chiang Kai-shek's government in China was signed at Nanking on September 9.



UNCONDITIONAL SURRENDER OF JAPAN, 1945. 1. Supervised by troops of the 25th Indian Division, Japanese officers lay down their swords at Kuala Lumpur after the official surrender at Singapore on September 12 of all enemy forces in Malaya. 2. Lt.-Gen. Takazo Numato (left) arrives at Rangoon with Rear-Admiral Kaigye Chudo, August 26, to discuss details of local surrenders.



3. On board H.M. Aircraft-Carrier Indomitable, at anchor in Victoria Bay, the Japanese envoy Makimura leaves after discussing plans for the surrender of Hong Kong, which took place on September 16. 4. Colonel Kaidi Tatsuishi surrenders all Japanese forces in Netherlands Timor, September 11, to Brigadier L. G. H. Dyke, Australian Army (with his back to the camera) : they are on board H.M.A.S. Moresby in the Bay of Koepang. 5. The Japanese foreign minister Mamoru Shigemitsu signs on his country's behalf the instrument of unconditional surrender to the Allies : the ceremony took place at 10.30 a.m. (local time) on September 2, 1945, on board the U.S.S. Missouri, at anchor in Tokyo Bay. With his back to the camera (left) is General Douglas MacArthur. Behind him are other Allied representatives; behind Shigemitsu are the members of the Japanese surrender delegation. Allied occupation troops, the majority of them American, went ashore during September 4.

LESSON 33

The "Cold" War

THE fighting over, the Allies occupied Germany and Japan. In Japan military government was established and proceeded smoothly, for there it was virtually a U.S. occupation, with General Douglas MacArthur as dictator, 1945–1951. Russia, which had come into the Pacific war a week before the end of the campaign, was not invited to co-operate ; and the other Western Allies were represented by a token force. A democratic form of constitution was introduced in Japan in 1946, and in September 1951 a treaty of peace between Japan and 49 of the countries which had fought against her was concluded at San Francisco. (Neither Russia nor Communist China had been invited to the treaty-making.)

Post-War Germany

In Germany the situation was very different. In accordance with plans agreed on before fighting ended, the country was divided into British, American, French, and Russian zones of occupation ; to fulfil these agreements, U.S. forces were withdrawn from a substantial area they had conquered. The German capital, Berlin (which lay within the Russian zone), was divided into four sectors. An Allied Military Government was set up in Berlin, and the Western Allies assumed that there would be joint administration of the conquered country.

It soon became apparent, however, that the ideas of the U.K., the U.S.A., France, and those of Russia, were widely different. The first intention of Russia (not unnaturally, in view of the appalling losses she had suffered by German invasion) was not to rehabilitate Germany, or even helpless Austria (an early victim of Nazi invasion, and now divided, like Germany, among the four Allies), but to take out of the Russian zones in the two countries all movable machinery and equipment (including railway lines), and as large a part of current production as possible, in order first of all to rebuild her own damaged factories and transport system. In 1948 all pretence at co-operation was abandoned: the Russians walked out of the "Kommandatura" on June 16, 1948, never to return, and attempted to starve the Western Allies out of Berlin by prohibiting any surface transport by land or water through their zone from Western Germany to Berlin ; this blockade was complete from July 10, 1948, to May 12, 1949. The Western Allies replied by organizing an "air lift" that, for 15 months (June 25, 1948, to September 30, 1949) kept their part of the city supplied with food, clothing, medical needs, and fuel, to the extent of more than 2,000,000 tons.

Self-government was gradually restored to the three zones of Western Germany. With the object of establishing a central German government for these zones, a constituent assembly met at Bonn on September 1, 1948 ; and on May 23, 1949, the Federal Republic of (West) Germany came into existence, with its capital at Bonn. Adherence of eastern Germany, and the removal of the capital to Berlin, were hoped for at some future date. Military government ended on September 21, and an Allied High Commission took its place. In the course of 1951 the three Western Allies ended the state of war between themselves and Germany.

The Russian response to the Western Allies' progressive liberation of Germany was to proclaim on October 7, 1949, the establishment of a "democratic German republic" in their zone, with east Berlin as capital. The area was given a Russian-Communist form of government with elections in which candidates of only one party stood. Refugees crossed continuously from east to west Germany, and from east to west Berlin, dissatisfaction in east Germany culminating on June 17, 1953, in a rising in east Berlin that spread to most of the eastern zone. The Russians suppressed it, with bloodshed ; but the tightness of their control was thereafter somewhat eased ; and in August delivery of reparations was cancelled as from January 1, 1954.

Peace Treaties

Treaties of peace between the Allies and Italy, Rumania, Bulgaria, Hungary, and Finland (the U.S.A. had not been at war with Finland) were signed in Paris in 1947 after acrimonious and long-drawn-out meetings of Allied representatives. Italy ceded to France four small frontier areas ; to Greece the Dodecanese ; to Yugoslavia a number of Adriatic islands, the Zara (Zadar) enclave, and most of Venezia Giulia ; she renounced all rights in her former African colonies : Tripolitania and Cyrenaica were formed into the kingdom of Libya, 1951 ; Eritrea was federated with Abyssinia, 1952 ; and Italy was given a ten-year United Nations trusteeship of (Italian) Somaliland from 1951. Italy also surrendered Trieste and part of the Istrian peninsula to form a free territory of Trieste (this area remained in Allied occupation until in 1955 it was divided between Italy and Yugoslavia, Italy recovering Trieste).

Rumania ceded Bessarabia and part of Bukovina to Russia. Hungary was reduced to her 1938 boundaries, with a minor rectification on the right bank of the Danube opposite Bratislava in favour of Czechoslovakia.

Bulgaria was confirmed in her possession of the southern part of the Dobruja, taken from Rumania in 1940. Finland ceded Petsamo to Russia, which thus acquired a common frontier with Norway.

War Crimes Trials

In May 1945 all those parts of Europe which had been in German occupation, and over which land and air battles had been fought for more than five years, were left with disrupted communications and industries, damaged towns, and a legacy of political bitterness. While many of the Germans responsible for this wretched condition of Europe were being brought to trial at Nuremberg (Germany), France, Belgium, the Netherlands, and the countries of the Balkans put on trial those of their citizens who had collaborated with the enemy and punished them. The trials at Nuremberg, lasting from November 20, 1945, to August 31, 1946, of 24 leading Nazis accused of war crimes ended in death sentences on 12, among them Goering (who evaded the hangman by committing suicide in his cell), Ribbentrop, Jodl, Seyss-Inquart, and Streicher. Hjalmar Schacht, a banker, Fritz von Papen, politician and diplomatist, and Hans Fritsche, an official of the Nazi propaganda ministry, were acquitted ; others tried were sentenced to various periods of imprisonment. Hundreds of lesser Nazis were subsequently brought before Allied or German courts and many were punished by death or imprisonment.

Similar trials in Tokyo of 28 leading Japanese, lasting from May 3, 1946, to November 12, 1948, resulted in seven death sentences, 18 sentences of imprisonment.

U.N.R.R.A.

Following up the Allies' armed forces liberating occupied Europe came the United Nations Relief and Rehabilitation Administration, set up already, with the backing of 44 nations, on November 9, 1943. This beneficent organization, which came to its official end on December 31, 1946, and was wound up six months later, probably saved Europe from anarchy. It fed and clothed millions in their own countries, and it helped to repatriate some 7,000,000 "displaced persons"—people dragged by the Germans from their homes to labour in German factories or to lie in German concentration camps.

Italy received nearly 10,000,000 tons of supplies ; Greece 2,700,000 tons ; Yugoslavia 2,400,000 ; Poland nearly 2,000,000 tons ; Czechoslovakia 1,550,000 tons ; Austria just over 1,000,000 tons. Other recipients of UNRRA help were the Ukraine, Albania, White Russia, and Hungary, the Philippines, Korea, and Abyssinia. The U.S.A. contributed $2,500,000,000, the U.K. £155,000,000, Australia £12,000,000, New Zealand £2,600,000, Canada $77,000,000 to this great work.

As well as displaced persons helped by UNRRA, thousands of others made their way home unaided as soon as the fighting ceased ; a special body had to be created by the United Nations to deal with hundreds of thousands who, because of post-war frontier changes, either could not or would not return to their places of origin ; and also with new refugees continually arriving in Western Europe from east Germany, and Germans (or people of German ancestry) expelled from Polish-occupied Pomerania and German Silesia, and from Czechoslovakia. Many unfortunate people were still living in encampments in west Germany more than three years after the refugee organization was wound up on December 31, 1951.

European Recovery

Belgium's economic recovery was rapid. Apart from flying bomb destruction at Antwerp she had suffered comparatively little damage, and she found herself enriched by U.S. dollars paid for bases set up on Belgian soil for American forces during the invasion and occupation of Germany, and for the invaluable strategic materials of the Congo. Politically, however, Belgium's immediate post-war history was unhappy. Leopold III's decision to remain in his country after its conquest by the Germans in 1940 was a political error of the first magnitude, and civil war seemed imminent between those who favoured his continuance as king and those who demanded his

WAR CRIMINAL'S FINAL PLEA. Nazi leaders before the International Military Tribunal at Nuremberg, on August 31, 1946. Goering declared, "Never did I decree a murder . . ."

abdication before, at last, on August 1, 1950, he agreed to delegate his powers to his son Baudouin who was installed as Prince Royal on August 11 and, following his father's abdication on July 16, 1951, was enthroned as king of the Belgians July 17, 1951.

Economic conditions in the Netherlands at her liberation could hardly have been worse ; and her East Indian colonial possessions had been lost. The Japanese, while in occupation of the Indies, had fostered the independence movement there ; fighting followed the Japanese surrender in 1945, and in 1949 the Netherlands government transferred sovereignty to the United States of Indonesia, brought under the control of the strongest member of the union, the Republic of Indonesia, during 1950. An attempt to set up a union between independent Indonesia and the Netherlands was abandoned in 1954. But despite the loss of the aid they might have received from East India's rubber and tin, the Dutch succeeded by hard work and self-denial in restoring their economy. Politically, the country proved strong. Wilhelmina's decision to abdicate after the celebration on August 31, 1948, of the golden jubilee of her assumption of full powers as queen was accepted as wise. Her popular daughter Juliana was enthroned on September 6.

France, divided by the German occupation into two parts during 1940–42, continued to suffer from this division. General de Gaulle landed in Normandy on June 14, 1944, and entered Paris immediately it was liberated on August 25. There he formed a government composed partly of members of the committee of liberation that had been sitting at Algiers since 1943, and partly of members drawn from the national council of resistance inside France, led by Georges Bidault. In November 1945 a newly elected constituent assembly elected de Gaulle premier ; but he had difficulties in forming a government, and in January 1946 suddenly resigned. A series of short-lived governments followed. But the weakness of her government did not prevent France from economic recovery ; and from the French foreign minister Maurice Schuman came the initiative which brought into being in 1952 the European Coal and Steel Community, a union for coal and steel production between France, West Germany, Italy, Belgium, the Netherlands, and Luxemburg, open to any other country that liked to join.

Marshall Aid

What chance Western Europe would have had of such rapid economic improvement without the help of the U.S.A. is debatable ; and in securing that help, Ernest Bevin, foreign secretary of the U.K., played the leading part. The U.K. was politically strong, economically very weak, at the end of the fighting. Dependent on trade and imports of food and raw materials for her living, which up to 1939 had been in large part paid for by "invisible exports" in the form of shipping and other services, and the interest payable on overseas investments, she had during the first 18 months of the war been obliged to sell overseas investments worth £1,118,000,000 to pay for necessary imports, chiefly from the U.S.A.

Lease-lend saved the war-time situation from March 1941 ; but President Truman's abrupt ending without notice of lease-lend shipments on August 20, 1945, left the U.K. in an almost desperate position. Lord Keynes negotiated a loan agreement for $3,750,000,000, ratified by Britain in December 1945, but not until July 13, 1946, by the U.S. Congress—by which time the internal value of the dollar had decreased, so that the loan was worth much less in goods when it became available than it had been when negotiated.

FIRST MEETING OF THE U.N. Delegates of the 51 nations which had ratified the United Nations Charter signed at San Francisco on June 26, 1944, met in the Central Hall, London, in January 1945 for the first session of the General Assembly. Here Mr. Attlee, the prime minister, welcomes them at the opening meeting, January 10.

On June 5, 1947, however, George Marshall, U.S. secretary of state, outlined a plan in an unofficial speech at Harvard by which U.S.

financial aid might be made available to Europe provided Europe itself could work out a satisfactory plan of self-help. Bevin immediately welcomed the "Marshall plan," and visited France to discuss ways of following up the American unofficial proposal. Russia was invited, but refused to take any part in working out a recovery programme ; but the U.K. and France on July 22 issued invitations to 22 European countries (omitting only Spain, Russia, and Germany, for which last country, however, the commanders-in-chief of the four zones were invited) to attend a conference in Paris on July 12.

GEORGE CATLETT MARSHALL, U.S. secretary of state 1947–49, on June 5, 1947, at Harvard, outlined the "Marshall Plan".

Refusals came from Albania, Bulgaria, Czechoslovakia (after an earlier acceptance), Finland, Hungary, Poland, Rumania, and Yugoslavia. Representatives of Austria, Belgium, Denmark, Eire, France, Greece, Iceland, Italy, Luxemburg, the Netherlands, Norway, Portugal, Sweden, Switzerland, Turkey, and the U.K. and of the three Western occupying powers in Germany, met and set up a committee of economic co-operation. By September this committee had drawn up for submission to the U.S. secretary of state a detailed statement, called the European Recovery Programme, showing the assets and needs of the participating countries for the subsequent four years.

On December 19, 1947, President Truman sent a message to Congress recommending the programme and asking for $17,000,000,000, to be paid out during April 1, 1948, to June 30, 1952. After exhaustive discussion Congress passed the Foreign Assistance Act on April 2, 1948. It included provision for $5,300,000,000 (reduced by the Foreign Aid Appropriation Act of June 14 to $4,000,000,000) to be spent on European recovery during the first 12 months of the plan ; and the Economic Co-operation Administration, with Paul G. Hoffman as administrator, was set up to handle Marshall Aid.

A second conference in Paris, March-April 1948, set up a standing representative body, the Organization for European Economic Co-operation. Bilateral agreements were made between the U.S.A. and each of the co-operating countries ; these envisaged greatly increased production in agriculture and industry, increased trade among member countries, limitation of imports paid for in dollars to goods necessary to recovery, and increase of exports to dollar countries. Further Congressional Acts provided funds for 1949 and 1950.

By December 1950 the trading position of the U.K. had improved to a point at which she was able to suspend acceptance of Marshall Aid from January 1, 1951 ; aid to Eire was suspended on May 2, 1951, to Sweden and Portugal on July 31, 1951, and the European Recovery Plan came to an end on December 31 that year. Its staff and functions were transferred to the Mutual Security Agency which came into being on January 1, 1952, and was designed to give economic aid to sustain and increase the military effort of receiving countries. During its three-and-a-half years' existence the Economic Co-operation Administration had allocated about $12,500,000,000 to Europe through the European Recovery Programme, and had succeeded in putting Western Europe on its feet again.

Western Union and N.A.T.O.

Alongside this remarkable record of international co-operation went a constantly closer co-operation between the countries of Western Europe and the U.S.A. in other spheres. With her traditional dislike of war and war service abroad, the U.S.A. had demobilised the bulk of her fighting services and turned over her war industry to peaceful production within a twelvemonth of the end of fighting. Europe, less optimistic, and also requiring more time to re-absorb its fighting men and women into civilian life, was less precipitate, and from Bevin again came the initiative that promoted common action among the Western Allies in face of increasing Russian hostility. By a 50-year treaty signed at Brussels on March 17, 1948, between the U.K., France, Belgium, the Netherlands, and Luxemburg, Western Union came into being.

COMMANDERS OF N.A.T.O. FORCES. Left to right : Col. Costa de Beauregard, France, aide to Field-Marshal Montgomery (U.K.), deputy supreme commander ; General Dwight D. Eisenhower (U.S.A.), supreme commander ; Admiral Robert B. Carney (U.S.A.), c.-in-c. Allied Forces, Southern Europe. From a photograph taken January 1951.

Permanent consultative and military bodies were created, as well as a committee to consider the further promotion of European unity. The U.S.A. looked with approval on Western Union, and on April 4, 1949, the North Atlantic Treaty was signed by the U.S.A., Denmark, Italy, Iceland, Norway, Portugal, and Canada, and the countries of Western Union. The treaty came into force on August 24, and an integrated North Atlantic Treaty Organization defence force was gradually built up, General Eisenhower on April 2, 1951, taking up office as supreme commander of Western European defences, with Field-Marshal Montgomery as deputy supreme commander. In February 1952 Greece and Turkey were admitted to membership of N.A.T.O. General Eisenhower resigned his appointment in 1952 in order to run, successfully it proved, as a candidate in the U.S. presidential election of November that year; he was succeeded by another American, General Ridgway, in turn succeeded in July 1953 by a third, General Gruenther.

Eastern Europe

While this spontaneous unity had been building up in Western Europe, Russia was increasing her grip on Eastern Europe. One after another the countries liberated wholly or in part by Russian forces came under Communist domination. Bulgaria, Rumania, Albania, Yugoslavia, Poland (despite her historic hatred of Russia), and last of all Czechoslovakia were saddled with Communist governments, many of them headed by exiles who had been trained in Moscow. In 1947 the "Cominform," a successor of the Communist International dissolved in 1943, was set up with headquarters at Belgrade. Communist rebels made a determined effort to bring Greece also into the Communist circle; but the expulsion of Yugoslavia in July 1948 from the "Cominform" on account of Tito's strongly nationalist resistance to Russian direction deprived the Greek rebels of their refuge across the Yugoslav border, and gave distracted Greece internal peace, the government being in full control of the country by the end of 1949.

ISRAEL PROCLAIMED A STATE. David Ben-Gurion, chairman of the Jewish Agency, broadcasts the proclamation of the setting up of Israel as an independent state May 14, 1948.

Poland, which under the Potsdam agreement was allowed to occupy Germany east of the Oder-West Neisse river line, pending a peace treaty with Germany, expelled from this territory all those Germans who had not already during 1944–45 fled before the advancing Russians, and filled it with the inhabitants of lands east of the Curzon line (ceded by Poland to Russia by a treaty ratified in January 1946) who did not wish to remain under Russian rule. The introduction in 1949 of Red Army Marshal Konstantin Rokossovsky, born in Russian Poland, as Polish minister of national defence and supreme commander of Polish armed forces, the Marshal taking Polish nationality, indicated the hold Russia had, and intended to strengthen, on Poland; and in November 1950 Poland and East Germany ratified an agreement proclaiming the Oder-West Neisse line as their common frontier.

The Near East

The broadcast proclamation at 4 p.m. on May 14, 1948, of the setting up of the Jewish republic of Israel in Palestine eight hours before the expiry of the British mandate for that country was only the most controversial of the developments in the countries of the Near East. Arab unity appeared to be achieved by this advent of a new state within the borders of the Arab countries; but that unity was short-lived, for the Israelis succeeded in keeping Lebanon, Syria, Transjordan, and Egypt at bay, and with United Nations' assistance signed armistices with one after the other. The last semblance of Arab unity vanished with King Abdullah's incorporation in 1950 into his kingdom of Jordan (as he had renamed Transjordan in 1949) of that part of Palestine still in Arab possession. Though surrounded by hostile neighbours, made more bitter by Israel's refusal to allow back within her borders or to compensate the more than a million Arabs who had fled from the area under Jewish control, the small republic, backed by funds provided by American Jewry and supported by the hard work of her citizens, managed to hold her own.

Egypt, which had stood by the Anglo-Egyptian treaty of 1936 during the Second World War, as soon as the war was over demanded its abrogation. Negotiations opened in May 1946 proved unfruitful of a settlement,

STRUGGLE IN VIETNAM. A helicopter ambulance comes in to the small French force beleaguered at Dien Bien Phu, 200 miles west of Hanoi, which held out against 40,000 Vietminh rebels from March 11 until May 7, 1954.

though agreement was reached by which British troops were withdrawn from both Cairo and Alexandria. But Egypt demanded also the evacuation of the Suez Canal zone, the end of the Anglo-Egyptian condominium in the Sudan, and the union of the Sudan with Egypt. In 1951 the Egyptian parliament unilaterally abrogated both the treaty of 1936 and the 1899 condominium agreement, and rejected at the same time an invitation extended to Egypt to take part in the creation of a new Middle East Command. King Farouk abdicated in July 1952 in favour of his infant son Ahmed Fuad. The proclamation of a republic with General Neguib as president followed in June 1953. A *coup d'état* in February 1954 brought Colonel Nasser to the top; and agreement was reached between the British and the Egyptians under which all military personnel were withdrawn from the Canal zone during 1955, British civilian groups taking over maintenance of essential installations, which were placed under the guard of Egyptian troops.

The Far East

The end of war between Japan and China did not end fighting in China where the Communists, led by Mao Tse-tung, brought all Manchuria under their control by the capture of Mukden on October 30, 1948, and advanced southwards; by the end of 1949 they had conquered all the mainland. Chiang Kai-shek flew to Formosa, where he maintained a government that the U.S.A. continued to support as the government of China. The Russians recognized the Communist government on October 2, 1949; the British recognized it on January 6, 1950. By the end of 1951 the Communists had made effective Chinese occupation of Tibet.

The presence just across the border of Communist-ruled China gave the rebel forces of Ho Chi-minh, who had been resisting the return of French rule in Indo-China since the end of the war, additional strength, and even some "volunteer" additional forces; and after a struggle involving the loss of several thousand Frenchmen, France in 1954 recognized the full independence of Annam, Tongking, and Cochin-China as the republic of Vietnam. The independence of the kingdoms of Laos and Cambodia France had already recognized in 1953.

Korea had been annexed by the Japanese in 1910. At the end of the Second World War all the Japanese were expelled from the country which the Allies had planned to make an independent republic. It was divided at the 38th parallel of north latitude into two zones of occupation, Russian in the north, U.S. in the south. All attempts by the United Nations to unite the two parts failed. A "democratic people's republic" was proclaimed in North Korea in February 1948; a republic in South Korea on August 15 of the same year. Russian troops left North Korea in December 1948; the last U.S. troops left South Korea in June 1949. A year later, on June 25, 1950, North Koreans invaded South Korea in force. An emergency meeting the same day of the U.N. Security Council (which the Russian delegate was at that

THE UNITED NATIONS HEADQUARTERS. The General Assembly building (left) and the towering 39-storey secretariat offices of the United Nations in New York, between 43rd and 47th Streets.

moment boycotting) declared this invasion a breach of the peace, and called in vain for an immediate cessation of hostilities. President Truman promptly placed U.S. troops at the disposal of the United Nations, and a force was landed in Korea from Japan. Their numbers were insufficient to hold the northern invaders, and the U.N. forces were driven back on Pusan.

Reinforcements arrived in September, and by the end of the month U.N. troops were again at the 38th parallel, which they crossed before a crumbling North Korean resistance. The campaign appeared to be over when Chinese Communist "volunteer" troops joined the North Koreans. The U.N. troops were compelled to retreat, and fighting swayed backwards and forwards among the hills near the 38th parallel. Negotiations at last started on July 10, 1951; it was two years before an armistice was signed. The south was left with a slight increase of territory; but union of the country seemed no nearer realization.

East-West Suspicions

The background to the distrust and hostility between Communist Russia and Communist China on the one hand and the Western Allies on the other was the threat and the fear of nuclear weapons. The U.S.A. had actually used atomic weapons against Japan; and this did not ease old Soviet suspicions of that country which had not been dissipated (as had those of most Americans) by the enforced alliance of the two countries in the Second World War. At the end of the war the U.S.A. believed herself to be at least ten years ahead of any other nation in atomic science. But in September 1949 Washington announced that an atomic explosion had occurred in the U.S.S.R., and in March 1950 Marshal Voroshilov stated that Russia possessed atomic bombs.

In the same month the brilliant scientist Klaus Fuchs, a naturalised British citizen who had fled from Germany before the war, was sentenced to 14 years' imprisonment under the Official Secrets Act: without any monetary reward, but through what he came to consider a misplaced faith in the purity of Russian Communist motives, he had given away essential details relating to the construction of the atomic bomb which may well have saved the Russians years of research.

The U.S.A., the U.K., and Russia continued their experiments in the development of these weapons; and in a situation in which international friendship and co-operation offered the only hope of national survival, the east continued to harbour suspicion of the west, and vice versa.

Then, on March 5, 1953, Stalin died. On August 29 Russia proposed a conference on Austria; on May 15, 1955, a peace treaty with Austria was at last signed, and that country regained its independence on July 27. During this same July 1955 a meeting in Geneva between Eisenhower, president of the U.S.A., Sir Anthony Eden, prime minister of the U.K., Edgar Faure, premier of France, and Bulganin, premier of the U.S.S.R., ended in an atmosphere of goodwill which by the end of the year had relapsed into the cold war unhappily normal between Russia and her war-time Allies.

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SHORTHAND

THIS Course presents the basis of Pitman's system of Shorthand, one of the oldest and perhaps most generally used of existing systems of rapid writing. Generally considered as a mere bread-and-butter subject for typists, a form of drudgery tolerated for its employment value, shorthand is in fact a valuable aid to many forms of study. It is valuable not only for note-taking at lectures and talks but for the rapid recording of notes of reading, of reference material and of other forms of work and study, such as summaries and drafts. From this condensed series of Lessons a very fair grasp of the system can be obtained which only needs extended practice in dictation work to make it fully satisfactory.

8 LESSONS

LESSON PAGE

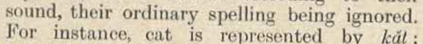
1. BASIS OF THE SYSTEM 532
2. WRITING VOWELS, CIRCLES, AND LOOPS 534
3. PHRASES AND DOUBLE CONSONANTS 540
4. THE USE OF HOOKS 545
5. COMPOUND CONSONANTS : THE HALVING PRINCIPLE 547
6. THE DOUBLING PRINCIPLE : PREFIXES 551
7. SUFFIXES AND DIPHONES 554
8. ADVANCED PHRASING AND DICTATION 556

LESSON 1

The Basis of the System

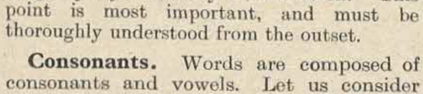
PITMAN'S Shorthand can be acquired easily by anyone of ordinary intelligence. It is a phonetic system; that is to say, words are written according to their sound, their ordinary spelling being ignored. For instance, cat is represented by *kăt*; cough by *kŏf*; knee by *nē*, and so on. This point is most important, and must be thoroughly understood from the outset.

Consonants. Words are composed of consonants and vowels. Let us consider the first group of consonants, composed of eight straight strokes, as follows:



The horizontal strokes are written from left to right, and the others are written downwards. The consonant *ch* (called *chay*) is the sound heard in such words as cheek and march, and *g* (called *gay*) the sound heard in give, bag, etc. These consonants should be practised until they can be written correctly and without hesitation. The size and thickness of the strokes shown above should not be exceeded. A pen with a fairly fine flexible nib and a ruled notebook should be used.

Consonants are joined, as in longhand, without lifting the pen, thus:



Vowels. Vowels are represented by dots and dashes written alongside the strokes.

Long *ā*, as in Tay, is represented by a heavy dot, thus, Tay, Kay, ache, tape, take.

Short *ĕ*, as in bet, is represented by a light dot, thus, egg, bet, peck, cheque or check.

Long *ō*, as in toe, is represented by a heavy dash, thus, Coe, oak, toe, Joe, joke.

Short *ŭ*, as in up, is represented by a light dash, thus, up, tub, duck.

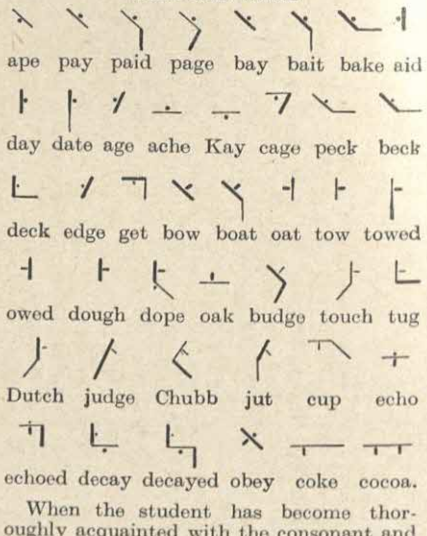
Note that the above vowel signs are written at the middle of strokes.

When a vowel is sounded before a consonant, the dot or dash is placed before the stroke; when a vowel is sounded after a consonant, the dot or dash is placed after the stroke. In the case of the horizontal strokes, a vowel which occurs before the consonant is written above, and a vowel which occurs after the consonant is written underneath. The consonant outline is written first, and then the vowel sign.

The learner will find that, if he has mastered the foregoing simple rules, he can already write in Pitman's shorthand quite a wide range of words. The words and shorthand forms in the following Exercise should be carefully studied and copied several times, until they can be written without hesitation.

EXERCISE 1

READ AND WRITE


ape pay paid page bay bait bake aid

day date age ache Kay cage peck beck

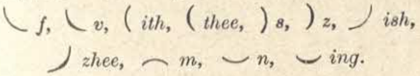
deck edge get bow boat oat tow towed

owed dough dope oak budge touch tug

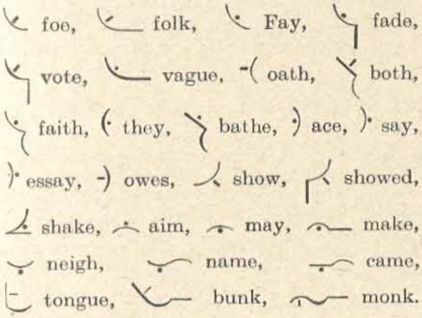
Dutch judge Chubb jut cup echo

echoed decay decayed obey coke cocoa.

When the student has become thoroughly acquainted with the consonant and vowel signs above explained, he should proceed with the study of a further group of consonants. In contrast to the eight straight strokes already given, the new group of consonants consists of shallow curves. Here they are:—



The first eight strokes are written downwards, and the remaining three from left to right. Careful study of the following words will reveal the exact consonantal value of these signs:—



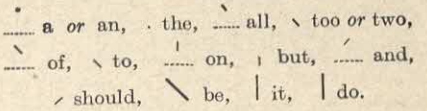
The difference in the sounds represented by the strokes (and (, as heard in the words both and bathe, should be specially noted.

Vowels. There are three places alongside a stroke in which vowels may be written; beginning, middle, and end; or first, second, and third place. The vowels already learned are written in the middle place, and are therefore called second-place vowels. The other vowels will be dealt with in succeeding Lessons.

In the above examples it will be noted that outlines consisting of horizontal strokes are written on the line, while in the other cases the first downstroke rests on the line. The position thus indicated is termed second position, and the words are so written because the first sounded vowel in the word is a second-place vowel.

Abbreviations. Certain frequently used words, such as be, it, of, are expressed in shorthand by a single sign. These short forms promote speed in writing, and should be thoroughly memorized. A small cross represents a full stop. Two short dashes beneath an outline indicate a proper name.

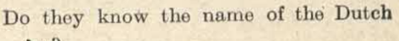
ABBREVIATIONS



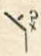
The signs for *and* and *should* are always written *upwards*.

The following Exercise should be carefully read and afterwards copied.

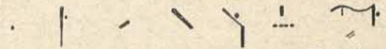
EXERCISE 2

1. 

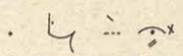
Do they know the name of the Dutch



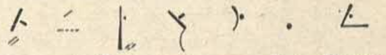
boat?

2. 

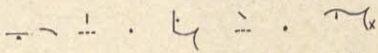
The debt should be paid on Monday



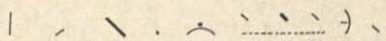
the tenth of May.

3. 

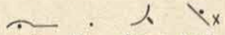
Joe and Ted both say the cheque



came on the tenth of the month.

4. 

It should be the aim of all of us to



make the show pay.

In order to test his knowledge of the rules so far explained, the reader should attempt to put into shorthand the following short Exercise, the key to which is given in the next Lesson.

EXERCISE 3

(*Abbreviations are shown in italic type*)

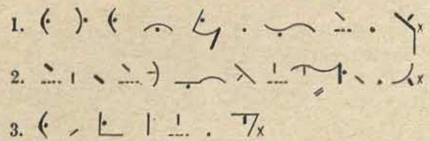
1. They say they may change *the* name *of the* boat.
2. *All but two of* us came up *on* Monday *to the* show.
3. They *should* take *it on the* coach.

LESSON 2

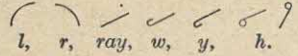
Writing Vowels, Circles, and Loops

The key to Exercise 3 given in Lesson 1 appears below, and the student should carefully note any errors. The correct forms should be written out several times to impress them on the memory. Other keys appear at the end of the following Lessons.

KEY TO EXERCISE 3



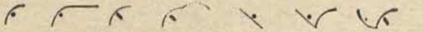
We will now consider the third and last group of consonants, namely:—



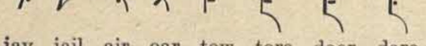
In the above group r and h are written downward. The others are written upward. All of them are light strokes.

The following words should be studied carefully, so that the exact value of these consonants may be appreciated.

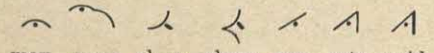
EXERCISE 4
READ AND WRITE



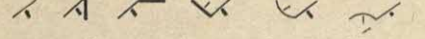
lay lake low loam pay pale fellow



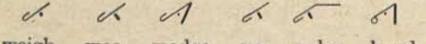
jay jail air oar tow tore door dare



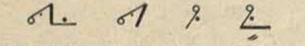
may mare show shore ray rate raid



row road rogue burrow furrow Murray



weigh woe wedge yo yoke head



headache hedge hay Haig

It will be seen that there are two forms of r, namely, downward r and ray (always written upward).

When a word begins with vowel-r, as air, oar, earl, or when r ends a word, use , thus, air, oar, earl, core, pair, tear, share.

When r begins a word or when a word ends with r-vowel, use , thus, row, rake, rug, rush, borough.

The above is the general rule for the writing of r, but in a few cases, in order to avoid awkward joinings, the rule is not strictly adhered to, as in (a) Rome, rum, firm; (b) urge, earth; (c) roar, rare.

The rule for the use of the strokes h is simple. Use when it stands alone, or is followed by — k, — g, and the upward form in other cases, thus, hay, hake, hoe, hope, hub, head, hung.

Here are the four vowels which are written in the first place, that is, at the beginning of a stroke:—

Long *ah*, as in pa, is represented by a heavy dot, thus, pa, palm, tar, far, farm.

Short *ă*, as in at, is represented by a light dot, thus, at, tap, back, lack, rack.

Long *aw*, as in saw, is represented by a heavy dash, thus, saw, jaw, bought, talk, law.

Short *ŏ*, as in top, is represented by a light dash, thus, top, shop, got, lock, wash.

An examination of the above outlines will show that when the first sounded vowel in a word is a first-place vowel, the outline is written in the first position, that is, the first downstroke or upstroke in the outline is written above the line.

ABBREVIATIONS

ought, who, put, to be,
had, different-ce, much,
which, large, can, come,
go, give-n, for, have.

When the foregoing rules and abbreviations have been mastered, Exercise 5 should be attempted. The key is given in page 539.

EXERCISE 5

1. Murray *and* Farrow *can come to the* show *to be given on* Monday.
2. *The* head *of the* firm may *have to go to* Assam *for a* month or *two*.
3. They *had a large* lock *put on, which ought to* make *much difference*.

The remaining four vowels are written in the third place.

Long ē, as in eat, is represented by a heavy dot, thus, eat, tea, eke, key, teak, team, lea, leak.

Short ĭ, as in if, is represented by a light dot, thus, if, bit, bill, bilk, chill, mill, milk.

Long ōō, as in chew, is represented by a heavy dash, thus, chew, Jew, cool, move, food, boot.

Short ŏŏ, as in book, is represented by a light dash, thus, book, look, took, pull, push.

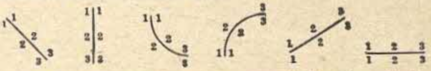
It should be noted that when a third-place vowel occurs between two strokes the vowel sign is placed before the second stroke.

The following tables set out clearly the long and the short vowels.

LONG		SHORT	
1. ah ·	aw –	1. ă ·	ŏ –
2. ā ·	ō –	2. ĕ ·	ŭ –
3. ē ·	ōō –	3. ĭ ·	ŏŏ –

The long vowels are heard in the sentence: Pa, may we all go too; and the short vowels in the sentence: That pen is not much good.

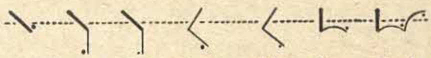
It should be remembered that the places of the vowels are counted from the point where the stroke begins: thus,



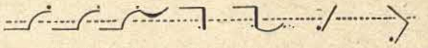
When a third-place vowel is the first-sounded vowel in a word, the outline is written in the *third* position, that is, the first downstroke or the first upstroke is written through the line. Outlines consisting of horizontals taking third position are written on the line, as ink.

EXERCISE 6

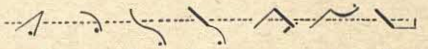
READ AND WRITE



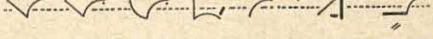
bee beat bit cheap chip dim dimly



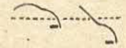
keel kill killing kid kidney each peach



reach ear fear beer ruby ring book



pull pulley fully tomb loom rude Goole



moor poor

The very frequently occurring consonant *s*, and its corresponding heavy sound *z*, are represented by a small circle as well as by the strokes) *s* and) *z*. This small circle joins easily to other consonants at the beginning, middle, or end of a word, and is a great aid to speed. At the beginning of a stroke the circle is read first; at the end of a stroke it is read last. Used initially, the circle represents *s* only, but in the middle or at the end of an outline it may represent *s* or *z*. The following simple rules should be carefully studied.

Circle *s* is written inside a curve, thus, safe, seem, sole, slow, nose, snows, insane.

Circle *s* is written with the *left* motion to straight strokes, thus, sat, said, set, sets, such, soak, soaks.

Circle *s* is written outside of the angle formed by two straight strokes, thus, desk, sixty, opposite, justice, dispose.

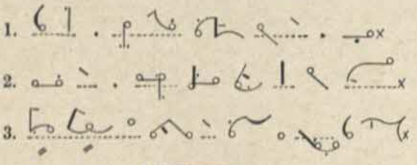
Note chasing, dozen, lisp, fasten, in which the angle is not formed by two straight strokes.

ABBREVIATIONS

as *or* has, is *or* his, itself, because, those, this, thus, special-ly, speak.

EXERCISE 7

COPY AND TRANSCRIBE



EXERCISE 8

WRITE IN SHORTHAND

1. *The* books *should be put on the* ledge *and thus* save space.
2. *Because of the special* packing case *the* car came safely.
3. He *has a large* salary *because of his special* abilities.

Keys to Exercises 5–8 in page 539.

Loops. A small loop, written in the same direction as the circle *s*, represents the light or heavy sound of *st* (named stee), thus, sop, stop, said, stead, Tess, test, raise, raised, face, faced, lace, laced, last, ballast.

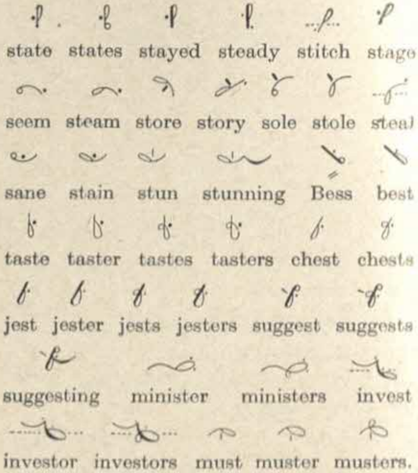
A large loop, also written in the same direction as the circle *s*, represents the sound of *str*, thus, dust, duster, coast, coaster, mass, master, less, lest, Lester.

The circle *s* may be added to these loops, thus, cost, costs, coster, costers, nest, nests.

The *str* loop is never used at the beginning of a stroke. Note, therefore, such forms as sterling, stirrup.

EXERCISE 9

READ AND WRITE


state states stayed steady stitch stage
seem steam store story sole stole steal
sane stain stun stunning Bess best
taste taster tastes tasters chest chests
jest jester jests jesters suggest suggests
suggesting minister ministers invest
investor investors must muster musters.

Initial and Final Vowels. As a circle or loop at the beginning of a stroke is always read first, and at the end of a stroke is always read last, it follows that when a word begins or ends with a vowel sound we must use the alternative stroke consonants to accommodate the vowel signs. For example, in the words sack, sleep, the circle is used because the word begins with *s*; but in such words as ask, asleep, which begin with a vowel sound, the stroke form of *s* must be used in order to provide a place for the vowel sign, thus, ask, asleep.

In the same way, in race, police, honest, the circle or loop is used because *s* or *st* is the last sound. Compare racy, policy, honesty, where the vowel at the end makes a stroke consonant necessary.

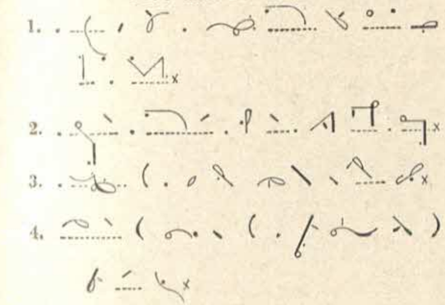
In deposit, visit, beset, the vowel between the *s* and *t* makes it necessary to write the circle *s* and *t*. For the sake of distinction from cost, the word caused is written .

ABBREVIATIONS

first, most, thank-ed, think, though, them, was, whose.

EXERCISE 10

COPY AND TRANSCRIBE



EXERCISE 11

WRITE IN SHORTHAND

1. Honesty *is the* best policy.
2. *Whose* job *is it to* see *to the* registers?
3. *It is to be* supposed they *thanked the* lad *for* adjusting *the* lists.
4. *Though the* costs may *be* heavy *the* barrister suggests they *should* appeal.

A large circle written at the beginning of a word, in the same direction as the circle *s*, represents the sound of *sw*, as heard in the following words: sweep, sweet, switch, swim, swing, swell, swear.

A similar large circle, written at the end of a stroke, represents the sound of *s-s* having a light or heavy sound, with the intervening vowel *ĕ*, as heard in the following words: paces, pieces, chases, taxes, boxes, laces, misses.

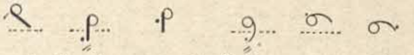
The large circle *ses* may be used in the middle of words, thus, necessary, necessity, successive, excessive.

Should any vowel other than short *ĕ* occur between the two *s's*, it may be indicated by writing the sign inside the circle, thus, insist, resist, Texas, basis, census, Mississippi, exhaust.

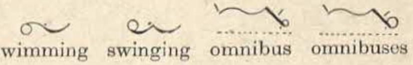
Final *s* is added thus, successes.

EXERCISE 12

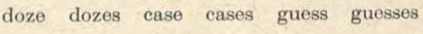
READ AND WRITE



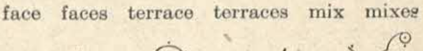
swab Swede swayed Swiss swam swim



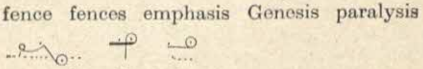
swimming swinging omnibus omnibuses



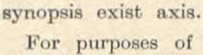
doze dozes case cases guess guesses



face faces terrace terraces mix mixes



fence fences emphasis Genesis paralysis



synopsis exist axis.

For purposes of distinction the large circle is not used in a few words ending in *s-s*. The following outlines should be carefully noted: possess, access, recess.

As policy, jealousy, Lucy, and other similar words are written with the stroke *s*, the stroke is retained in derived words, thus, policies, jealousies, Lucy's.

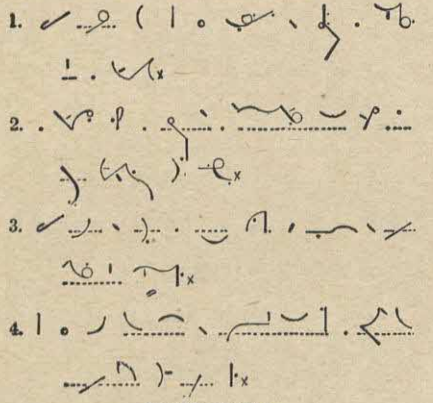
ABBREVIATIONS

shall, wish, usual-ly, me, him, in *or* any, own, language *or* owing, thing, young, themselves, are, our *or* hour, ourselves, we.

For obvious reasons, keys to the Exercises are given in later pages. Those for Nos. 5, 7–8, 10–11 and 13–14 are in page 539.

EXERCISE 13

COPY AND TRANSCRIBE



EXERCISE 14

WRITE IN SHORTHAND

1. *All the* boxes *are* ready, *and should be put on the* 8.50 a.m. *to* Manchester.
2. *In our own* case *we think our* policy *should* lead *to* success.
3. *Come and* see *me on* Monday or Wednesday, *and we shall* discuss *young* Swain's case.
4. *It is* no easy *thing to* master *a language, a* fact *on which* they *themselves* lay emphasis.

Diphthongs. There are four common diphthongs, or double vowels, namely, ī, *oi*, *ow*, and *ū*, as heard in the words I enjoy loud music. These diphthongs are represented as follows:—

ī, oi, ow, ū.

Note carefully, in the following words, how these signs are used: tie, my, joy, boy, loud, rowdy, beauty, cure.

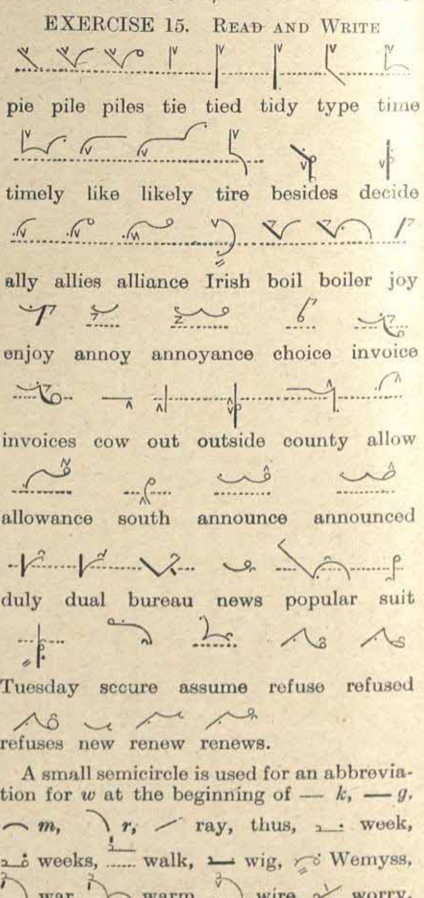
The signs ī and *oi* are written in the first vowel place; *ow* and *ū* are written in the third vowel place.

In a few cases, when an easy and facile joining can be made, at the beginning or end of words, the diphthong signs may be joined to consonants, thus, ice, eyes, item, isle, nigh, oiled, bow, due, few, now, value, review, now.

Note that, for greater convenience in joining, the *ū* sign may sometimes be tilted, as in value; and the signs for ī and *ow* abbreviated to a single tick, as in isle and now.

A small tick added to a diphthong sign indicates another vowel immediately following the diphthong, thus, buying, diary, loyal, towel, annuity.

EXERCISE 15. READ AND WRITE



pie pile piles tie tied tidy type time

timely like likely tire besides decide

ally allies alliance Irish boil boiler joy

enjoy annoy annoyance choice invoice

invoices cow out outside county allow

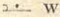
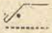
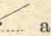
allowance south announce announced

duly dual bureau news popular suit

Tuesday secure assume refuse refused

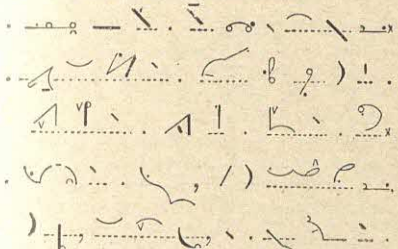
refuses new renew renews.

A small semicircle is used for an abbreviation for *w* at the beginning of — *k*, — *g*, *m*, *r*, ray, thus, week, weeks, walk, wig, Wemyss, war, warm, wire, worry, worth, worthy.

This semicircle is always read first. If a vowel begins a word, the stroke *w* must be used, thus,  wake, but  awake, ware, but  aware.

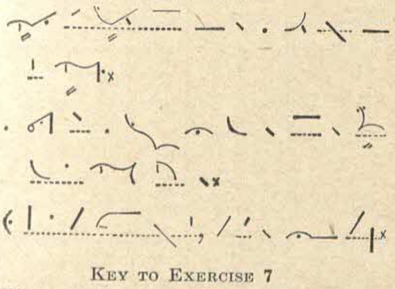
EXERCISE 16

READ AND TRANSCRIBE



Following are keys to Exercises given in pages 535 to 538. Any errors made should be carefully noted and the correct forms written several times to impress them on the memory.

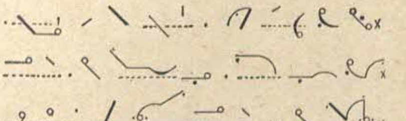
KEY TO EXERCISE 5



KEY TO EXERCISE 7

1. Those at the city office seldom speak of the case.
2. Six of the sixty desks chosen had special locks.
3. Thomas Johnson has hopes of selling his business this month.

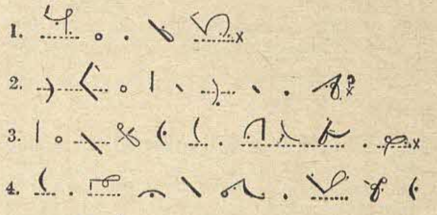
KEY TO EXERCISE 8



KEY TO EXERCISE 10

1. The thief who stole the minister's car posed as a guest at the party.
2. The speed of the car and the state of the road caused the skid.
3. The investors think the first step must be to stop waste.
4. Most of them seem to think the judge's summing-up was just and fair.

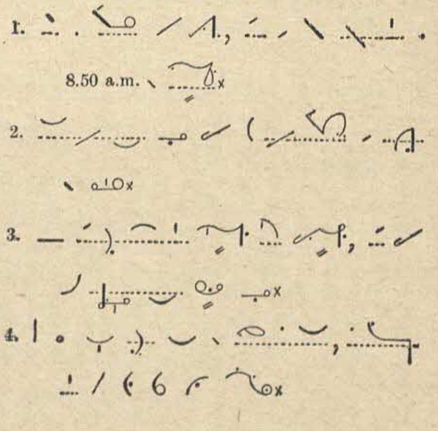
KEY TO EXERCISE 11



KEY TO EXERCISE 13

1. We ourselves think it is necessary to dispatch the notices on the fourth.
2. The police state the speed of the omnibuses in such a busy thoroughfare was excessive.
3. We wish to see the young lady who came to our offices on Monday.
4. It is usual for me to look in at the shop for an hour or so each day.

KEY TO EXERCISE 14



LESSON 3

Phrases and Double Consonants

A MOST interesting feature of Pitman's Shorthand is phrasing, that is, the joining of two or more words to aid fluency in writing. For instance, the forms for the words we have may be joined easily and without any loss of legibility, thus, In the same way, it should be may be joined, thus The increase in speed which must result from judicious phrasing will be obvious. Other examples of simple phrasing are it may be, it is, it was.

The extent to which phrasing is adopted is optional, but in joining words the following points must be kept in mind: (1) A phrase should be easy to write; (2) it should not ascend too far above or too far below the line; (3) it must be easy to read.

The first word in a phrase should occupy the position in which it would be written if standing alone. For example, a phrase beginning with the word for must start above the line, thus, for which; while a phrase beginning with may must start on the line, thus, may be. (It is seldom necessary to vocalize phrases.)

A small tick at the end of a word represents the. It is written either upward or downward, whichever forms the better angle from a speed point of view, thus,

(Down) of the, to the, and the, by the, have the.
(Up) at the, which the, was the.

This tick is never used initially or for the standing alone.

Note on the, and but the, which are slightly tilted to give a better angle.

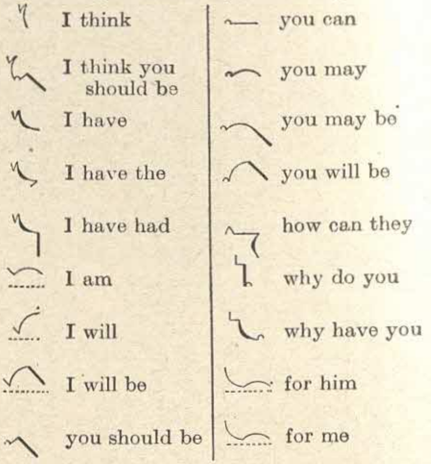
Before studying the following list of phrases, the reader should learn the following abbreviations:—

why, how, you, beyond, I, with, when, what, would, oh *or* owe, he.

In phrasing, the sign may be shortened to one tick before and , thus, I can, I am, I will (I'll).

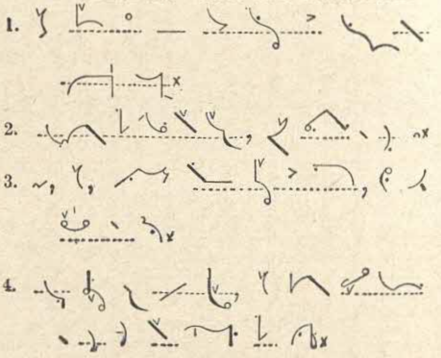
The word he standing alone, or at the beginning of a phrase, is written ; but in the middle of a phrase it is represented by the abbreviation ; thus, he may, if he may.

Phrases. The list of phrases given below should be carefully studied and copied until they can be fluently and accurately written. Aim at a light smooth style of writing.



I think	you can
I think you should be	you may
I have	you may be
I have the	you will be
I have had	how can they
I am	why do you
I will	why have you
I will be	for him
you should be	for me

EXERCISE 17. COPY AND TRANSCRIBE



Recapitulation. Before proceeding further with the study of the system it may be well to review briefly the main principles so far considered. It will be remembered that:—

(1) There are six long vowels, six short vowels, and four diphthongs, as illustrated in the following words:—

Long vowels: calm, fade, beat, chalk, coal, doom.

Short vowels: bat, check, chill, lock, Dutch, pull.

Diphthongs: dye, like, choice, boil, rowdy, couch, duty, Bute.

(2) When a word begins with a vowel followed by *r*, or when a word ends with the sound of *r*, the downward form is generally employed, thus, oar, ark, early, pier, jeer, share. Contrast these words with row, rack, rally, Pirrie, jury, sherry.

(3) The above rule is not strictly adhered to if an awkward form would result. Note Rome, remedy, earth, rage, roar, officer, razor.

(4) *H* standing alone, or followed by *k* or *g*, is written downward, thus, hay, he, hockey, Haig.

(5) A small circle at the beginning of a stroke represents the sound of *s*, and at the end of a stroke it represents *s* or *z*, thus, sat, sight, same, sane, sell, sells, smile, smiles, task, desk, desks, risk, risks.

This circle is written with the left motion to straight strokes, inside curves, and outside an angle formed by two straight strokes. Where a word begins with the sound of *z*, the stroke *z* is used, thus, zeal, zealous.

(6) A shallow loop, written in the same direction as circle *s*, represents the sound of *st*, and a large loop represents the sound of *str*, thus, state, stood, stitch, stitches, stem, stole, roast, roaster, dust, duster, dusters, minister, Axminster.

The *str* loop is never used at the beginning of a stroke. Thus we write sterling, sterilize.

(7) A large circle at the beginning of a stroke represents *sw*, and at the end of a stroke *sez* or *ses*, thus, sweep, switch, cause, causes, race, races, census, exist.

ABBREVIATIONS

subject-ed, several-ly, your, year, influence, influenced, next, Lord.

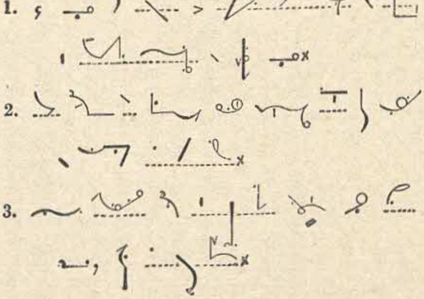
EXERCISE 18

WRITE IN SHORTHAND

(Phrases are indicated by hyphens).

1. Five *of-the* six cases were tied *with* thick rope.
2. I-*think-it-is* likely *you*-may see Davis *when you-are in* Leicester.
3. *A* few *of-the* guests *are* leaving early *on*-Monday, *and-the* rest *on* Tuesday.
4. "*The Influence of-the* Cinema" *is-the first of-the several subjects to be* discussed *next* season.
5. *Lord* Johnson used *his influence in several* ways *this year, and our next* appeal *should be a* big success.

EXERCISE 19. COPY AND TRANSCRIBE



Double Consonants : Hooks. To obtain briefer or more convenient forms, the double consonant strokes may be used even when a distinct vowel comes between a consonant and *l* or *r*. Where this special use of the double consonant stroke is made, a dot vowel is shown between a stroke and the *l* or *r* by writing a small circle instead of the usual vowel sign after (preferably) or before the stroke, thus, parcel, dark, darker, direct, directly, sharp, sharply.

In words like term, perceive, nervous, mercury, the hooked form sufficiently represents the first syllable, and the circle representing short *ĕ* may be omitted.

An intervening dash vowel or diphthong is shown by writing the vowel or diphthong sign through, or at the beginning, or at the end of the stroke, thus, corner, Burmah, tolerable, former, North, Norfolk, coarse, coarsely, before, purchase, occur, occurrence, church, lecture, lectures, capture, literature. Note the distinctive forms regard, regret.

This form of vocalization is not generally used for one-syllable words, where the consonants are separated by a strongly-sounded vowel. Note, for instance, pare, pale, dare, pole, dole.

ABBREVIATIONS

their, there, more, remark-ed, mere, Mr.; sure, pleasure; valuation; people, belief-believe-d; tell, till, deliver-ed-y; largely; call, equal-ly; surprise, surprised.

EXERCISE 23. WRITE IN SHORTHAND

1. *This* summer *Mr.* North *is to-deliver a* course *of* lectures *on* "Ciphers *and* Codes."
2. *We-have-pleasure in* enclosing *a* few *more* copies *of-the* brochure *on "The Valuation of-*Property," *which, we-are-sure, should-be of* service *to Mr.* Strange.
3. Many *people* expressed *their surprise* at-*the* strong *remarks of Mr.* Soper.

KEYS TO EXERCISES 16–20

When the student has corrected his rendering of Exercises 16 and 17 from the Keys given below, he should have each exercise dictated to him several times. Vowel signs may be omitted in this practice. A light touch is essential in speed work

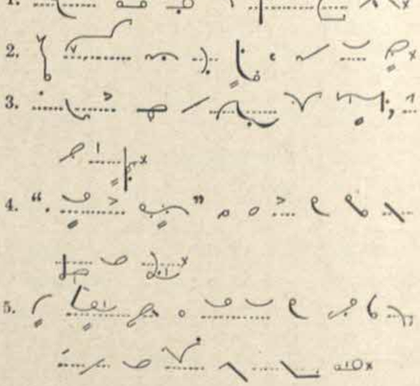
KEY TO EXERCISE 16

1. The excuse given by the boy seems to me to be weak.
2. The youth in charge of the lorry states he was on the right side of the road at the time of the smash.
3. The failure of the firm, which was announced last week, was due, in my view, to the poor work of the buying staff.

KEY TO EXERCISE 17

1. I think the time has come for the affairs of the firm to be looked into.
2. If you will be at the office by five, I shall be happy to see you.
3. You should, I think, renew the back tyres of the car, as they show signs of wear.
4. If he desires to have our advice, I think it will be wise for him to see us by Monday at the latest.

KEY TO EXERCISE 18



KEY TO EXERCISE 19

1. When the case was put to the jury by the counsel they took but forty minutes to decide the case.
2. For the work of taking the census two months ago it was necessary to engage a large staff.
3. Many officers were on duty at the Epsom races last week and they had a busy time.

KEY TO EXERCISE 20

1. Dr. Grace is still remembered by all who play cricket.
2. The large increase in the number of members of the club during the last few months is largely due to the care with which Dr. Draper has carried out his duties, and we think the numbers should steadily grow larger.

LESSON 4

The Use of Hooks

In Lesson 3 (page 540) the use of initial hooks was discussed. Now consider how hooks may be used at the end of strokes to represent *f* or *v*, *n*, and *shun*.

A small final hook, written on the same side as circle *s* to straight strokes, adds *f* or *v*, thus, pave, above, tough, dove, chafe, Jove, drive, drives, rough, wave, waves, serve, serves. Note how *s* is added by writing circle inside the hook.

A small final hook written on the opposite side to the *f*/*v* hook adds *n* to straight strokes, thus, pain, bone, tone, chain, Jane, cane, broken, run, won.

In order to express the addition of a final circle or hook to straight strokes hooked for *n* we simply write the circle or hook on the *n*-hook side of the stroke, thus, pine, pines, ban, bans, dine, dines, retain, retains, John, John's, gain, gains, against, expense, expenses, Dan, dance, danced, dances.

In the case of curved strokes, a small final hook represents *n*, circle *s* being added by writing the circle inside the hook, thus, mine, mines, line, lines, earn, earns. There is no *f*/*v* hook to curves.

These hooks may be used in the middle of outlines when they join easily to the following stroke, thus, defence, define, provide, refer, referring, reference, training, telephone, evening, arrange. Note meantime, minute, window, lounge, county, where the medial stroke *n* is preferable.

For the syllable *-ner* the sign is preferred, except after a straight upstroke, thus, keener, banner, liner, but runner, winner.

After a curved stroke the light sound of *-nce* is represented by stroke *n* with the circle added, thus, fence, lance, allowance.

When a vowel follows *f*, *v*, or *n* at the end of a word it is necessary, in order to place the vowel-sign, to use the stroke *f*, *v*, or *n*, as in coffee, cough, Duffy, Duff, funny, fun.

ABBREVIATIONS

been, general-ly, behalf, advantage, difficult, difficulty, within, southern, northern, opinion, balance, circumstance, significance, signify-ied-icant.

SOME USEFUL PHRASES

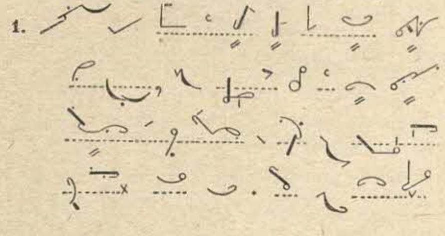
they are, I have been, we have been, had been, their own, our own, better than, more than, which have, out of.

EXERCISE 24

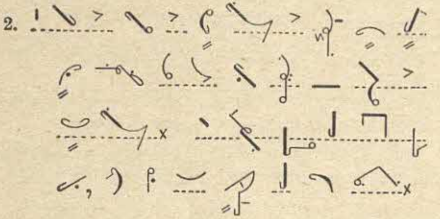
COPY AND TRANSCRIBE

(*Unimportant vowels are omitted*)

1.



2.



The -shun Hook. A large final hook adds the sound of -shun or -zhun. This hook is written inside curves, thus,

fashion, vision, division, provision, session, motion, promotion, commotion, mission, permission, nation, national, examination, lotion, relations.

There are several slight restrictions which must be observed by the student in the placing of the -shun hooks to straight strokes, and the following points should therefore be carefully noted.

When a straight stroke begins with a hook, circle, or loop, the -shun hook is written on the *opposite* side in order to balance the outline, thus, Grecian, aggression, section, station, expression.

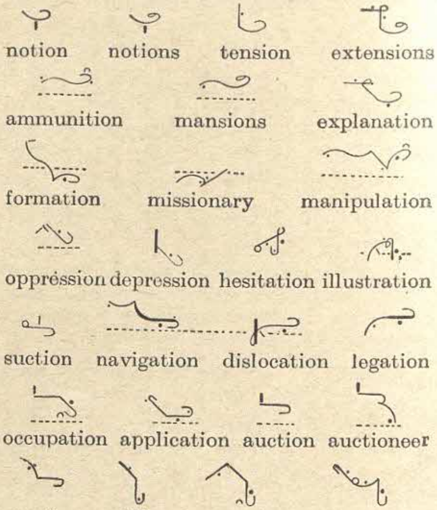
After and the -shun hook is written away from the curve, the reason again being a matter of balance, thus, fiction, vacation, location, selection.

The -shun hook is always written on the right-hand side of simple *t*, *d*, and *j*, thus, addition, edition, invitation, magician.

When added to the other simple straight strokes, it is written on the side opposite to the last vowel, thus, caution, occasion, actions, operation, ration, rational.

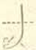
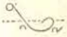
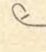
EXERCISE 25

READ AND WRITE



When -shun follows the circle *s* or *ns*, it is represented by continuing the circle to the other side of the stroke, thus, decision, position, proposition, possession, possessions, taxation, transition.

A third-place vowel between the *s* and -shun is placed as shown. Other vowels between *s* and -shun may safely be omitted.

In words ending in -uation, or -uition, the stroke *sh* and hook *n* are generally used, thus,  tuition, situation. In several such words, however, where there is no danger of confusion, the -shun may be used, thus,  superannuation,  fluctuation.

EXERCISE 26

WRITE IN SHORTHAND

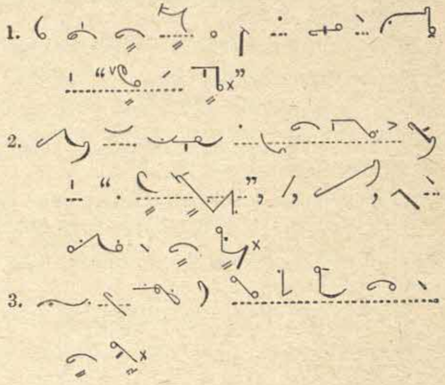
1. Fusion, infusion, evasion, revision, admission, admonition, elevation.
2. Celebration, discussion, infection, impression, transaction, Russian, Prussian, deputation.
3. Sensation, supposition, indecision, physicians, education, commissioner, obligation.

Keys to Exercises 24 and 26 above are given in page 551. At this stage it will be interesting for the student to have Exercises 22 and 23, keys for which are provided here, dictated several times so that he may accustom himself to writing from the spoken word.

KEY TO EXERCISE 22

1. With your approval, I shall speak to the traveller myself and make every endeavour to influence him in favour of the proposal.
2. The place of the gathering on Friday next is very near to the Waverley Hotel.
3. We think we shall be able to recover the missing valuables. The initial delay, however, is in favour of the thieves.

KEY TO EXERCISE 23

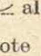
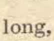
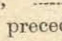


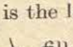
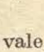
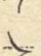
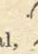
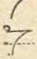
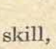
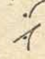
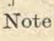
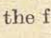
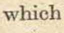
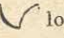
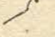
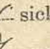
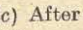
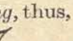
LESSON 5

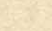
Compound Consonants: Halving Principle

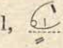
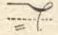
BEFORE proceeding further with the study of the theory of Pitman's Shorthand the reader would be well advised to check his attempts at Exercises 24 and 26 from the keys which are given in page 551. He can then turn to the consideration of the upward and downward *L* and the upward and downward *R*. It is always advisable to make certain that progress is soundly based and this can be done only by repeated practice and checking. Incorrect habits in stroke formation will be very difficult to cure at a later stage.

Upward and Downward L. There are one or two points in regard to the writing of stroke *l* to which attention is now drawn. In the first place it should be noted that *l* is usually written upward. In the following cases, however, it is written downward—

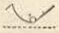
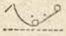
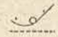
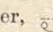
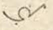
(*a*) At the beginning of a word when a vowel comes before *l* and the *l* is followed by a simple horizontal stroke, thus,  alone, along, Allen,  Alec. Note loan,  long, luck, where no vowel precedes the *l*.

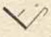
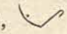
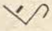
(*b*) When *l* follows  or a straight upstroke and the *l* is the last sound in the word, thus,  fall,  fill,  feel, full,  vale,  veal,  reveal, scale,  skill,  rule, rail,  barrel. Note the following words in which a vowel follows *l*:  folly,  fellow,  fellows,  lovely,  relay, sickly.

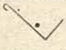
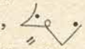
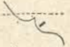
(*c*) After *n* or *ng*, thus, only, unless, canal,  wrongly.

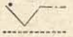
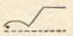
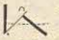
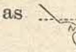
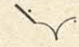
When *l* immediately precedes or follows a circle which is attached to a curve, it follows the direction of the circle, thus, listen, vessel,  Lawson,  Kingsley, muscle.

Upward and Downward R. The two forms of *r* have already been discussed in Lessons 2 (page 534) and 3 (page 540), to which reference should be made, if necessary. The following additional points should now be noted.

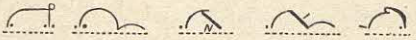
(*a*) Upward *r* is written after a curve and circle in such words as  officer,  officers,  answer,  sincere,  necessary, where the downward form would be somewhat awkward.

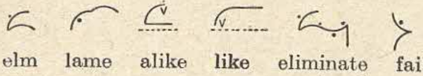
(*b*) When the *r* is hooked and follows another stroke it is generally written upward, thus,  burn,  fern, adjourn,  portion.

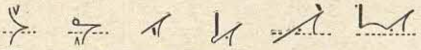
(*c*) After two downstrokes the upward *r* is preferable, thus,  prepare,  Shakespeare, in order to avoid three descending strokes. After *f* or *v*, however, the downward *r* is preferred because of the more flowing form, thus,  pinafore.

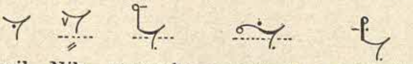
Medially the upward *r* is usually preferred, as in  park,  mark,  durable. In some derivative words, such as  powerful,  barely, the downward *r* is retained.

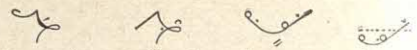
EXERCISE 27. READ AND WRITE

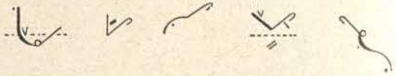

laxity alarm allowable album Oliver


elm lame alike like eliminate fail


file scowl roll dwell rural admiral


nail Nile strongly seemingly suddenly


nervously refusal Spencer sincere

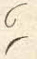

adviser torn learn Byron persevere.

EXERCISE 28

WRITE IN SHORTHAND

1. *The* damage *to-the* car *was* heavy, *as-the* speed *of-the* lorry at-*the*-time *of-the* collision *was* said *to-be* forty miles *an hour* at-least.
2. *We* hope *you*-will receive-*the* rest *of-the* rugs *from* Lawson *and* Barrie *in two* or three days.
3. *In*-answer *to-your* application, *we-are* enclosing full details *of-the* Burns alarm bell. If-*you* so desire *we-shall* ask *our* traveller *to-call and* see *you*.

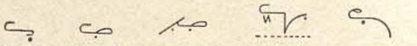
Compound Consonants. In addition to the double consonants formed by the initial hooks *r* and *l*, we have what are termed compound consonants, as set out below—

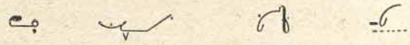
Sign	*Name*	*Letters*	*As in*	
	Kwā	QU	*qu*ick,	re*qu*est
	gwā	GW, GU	*Gw*ynn,	lin*gu*ist
(up)	wel	WL	*w*ai*l*,	*w*i*l*d
 (up)	hwel	WHL	*wh*i*l*e,	*wh*ee*l*
(down)	ler	LR	fee*ler*,	scho*lar*
(down)	rer	RR	fai*rer*,	poo*rer*
	emp	MP, MB	da*mp*,	e*mb*alm
	hwā	WH	*wh*ere,	*wh*ip

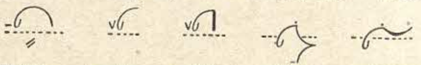
The illustrations in Exercise 29 show clearly the exact value of these signs.

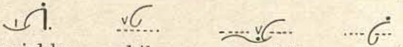
EXERCISE 29

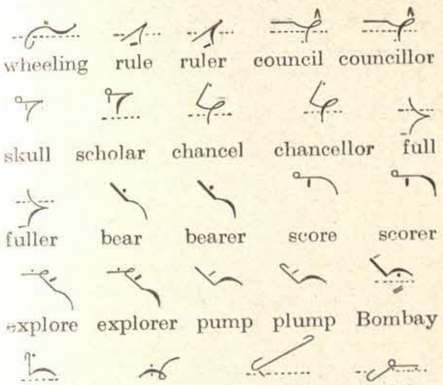
READ AND WRITE


queer quest request quietly square


squeeze enquiry well-dressed wall


Waller wile wild wilful willing


unwieldy while meanwhile wheel



The initial hooks in *wl* and *whl* are read first, so that if a vowel precedes the sound of *w* the stroke form of *w* or *wh* must be used, thus, while, but awhile. The form of *l* or *r* which is used in the root word is retained in the derivative, thus, toil, toiler; jail, jailer; fill, filler; score, scorer; fair, fairer. The use of the form *rer* is confined to derivatives of words taking the downward *r*.

These thickened forms *lr*, *rr* are not used finally if a vowel follows the *r*, as fuller, but foolery.

The heavy sign may be hooked, thus, scamper, lumber, dampen, ambition. The sign, however, is not used when one of the four double consonants *pr*, *br*, *pl*, or *bl* immediately follows *m*. Compare empress with emperor; imply with impel.

EXERCISE 30

WRITE IN SHORTHAND

1. At-*the* request of Councillor Quinn, I-enclose fuller details *of-our* "Empire" cars.
2. While *we-have* every sympathy *with you and are* willing *to* assist *in-any*-way possible, *we shall* require *you to put-the* facts *in a much* clearer manner.

Aspirate. It will be remembered that in Lesson 2 (page 534) the use of the two-stroke forms of *h* was discussed. The rule then explained was to the effect that before *k* or *g*, or when standing alone, *h* was written downwards, thus, Hogg, Haig, he, high, and that generally the upward form was most convenient for joining to other consonants, thus, hope, head, hedge, heavy, history, hotel, half, hence, houses.

Note specially the following examples of stroke *h* being used medially: behave, adhere, overhaul, mahogany. Before the strokes, however, the downward *h* is reduced to a tick, thus, home, whom, Hamilton, hail, health, help, holding, holiday, hair, here, herself, horse.

In some cases the use of the stroke *h* medially would give an awkward or lengthy outline, and here the *h* is represented by a light dot placed before the vowel, thus, manhood, neighbourhood, likelihood, leasehold, perhaps.

Halving Principle. We come now to a most important principle, a knowledge of which will enable the learner greatly to increase his vocabulary. The following rules should be noted most carefully:—

In one-syllable words, a *light* stroke is halved to indicate, without actually writing, a following *t*, thus, fay, fate, lay, late, fie, fight, lie, light, may, mate, knee, neat, no, note, notes. In the word *notes* it will be seen that the circle *s* is, as usual, read last at the end of the word.

Similarly, in one-syllable words, a *heavy* stroke is halved for the addition of *d*, thus, die, died, guy, guide, love, loved, move, moved, charge, charged.

In words of two or more syllables, however, a stroke is halved to indicate the addition of either *t* or *d*, thus, credit, debit, rabbit, applied, little, noted, visited.

Note bit, plied, one-syllable words where the strokes must be written in full. Compare them with debit and applied, two-syllable words.

ABBREVIATIONS

information, satisfaction, justification, generalization, whether, important, improve-d-ment, impossible.

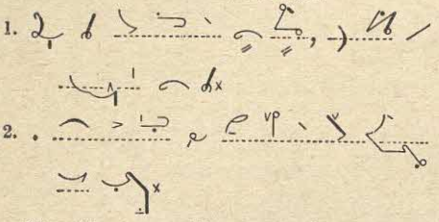
EXERCISE 31

WRITE IN SHORTHAND

1. Acting *on information* received, *two* officers visited *the* Hamilton Hotel *in* Haddow Road, *and* took many notes.
2. *It-is impossible to* say yet *whether* or not *the* change will-*be an improvement*.

EXERCISE 32

COPY AND TRANSCRIBE



We will now consider the further application of this very useful principle. When a stroke has a finally-joined diphthong, or a final hook, it may be halved for *t* or *d*, thus, bout or bowed, about, doubt, proud; issued, mute, feud; paint or pained; bent or bend; tent or tend; repent, ripened; meant or mend, amounts, amends; rent or rend, rents or rends.

Half-length *h*, when not joined to another stroke, is always written upwards, thus, height, heights, hound, hounds.

Where the half-length upward *r* would stand alone, or with only a final *s* added, it is preferable to write the *r* and the *t* in full, as in right, rights. Half-length *r* might be misread for *and* or *should*.

The strokes *m* and *n* are halved and thickened to indicate a following *d*, thus, made, mud, ashamed, modern, middle; end, need, sound, intends, undoubtedly.

Downward *l* and downward *r* are halved and thickened to indicate a following *d*, thus, old, bowled, filled, world; bored, heard, hardly, wired, standard.

When a vowel comes between l-d or r-d, the full strokes are written, thus, card, but carried; marred, but married.

Final *lt* is expressed by, and final *rt* is usually expressed by, thus, belt, start.

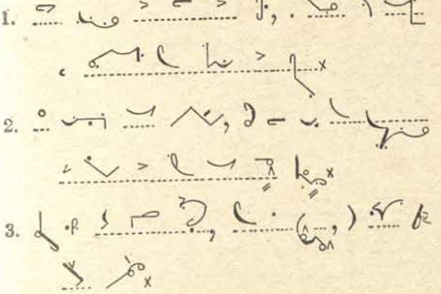
Unless the junction is quite clear, strokes of unequal length should not be joined. For instance, in the outline for *effect* half-length *k* would not be clear: the outline must therefore be used. To show the difference in size, disjoin half-length *t* or *d* when they follow strokes *t* or *d*, thus, credited, treated, dictated.

ABBREVIATIONS

quite, could; accord-ing (to), cared; guard, great; called, equalled, cold; gold; that, without; wished.

EXERCISE 33

COPY AND TRANSCRIBE



The Keys to the Exercises in this Lesson are given opposite and in pages 553—554.

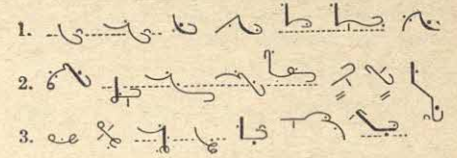
Following are given the Keys to Exercises 24, 26, 28 and 30. After any mistakes have been noted it is suggested that the exercises be taken down from dictation at increasing rates of speed.

KEY TO EXERCISE 24

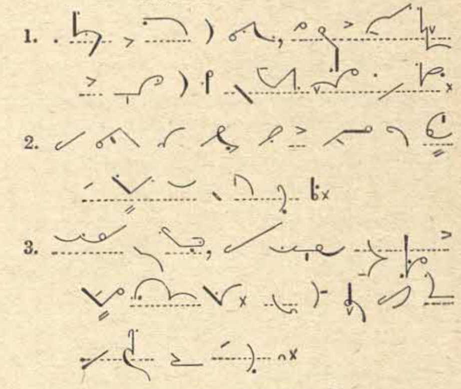
1. Referring to our talk with John Dunn at the Northern Hotel last evening, I have discussed all the circumstances with Mr. Henry Bannerman and he promised to arrange to have the books gone through again. In his opinion the balance should have been more than twice the figure now given.

2. On behalf of the members of the Southern branch of the society Mr. John Lane expressed thanks for the able assistance given by those of the Northern branch. All possible difficulties had been got out of the way, and their stay in Rushton had been very happy.

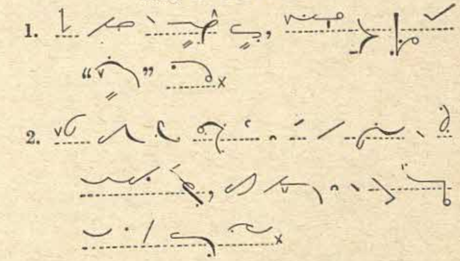
KEY TO EXERCISE 26



KEY TO EXERCISE 28



KEY TO EXERCISE 30



LESSON 6

The Doubling Principle: Prefixes

HAVING checked his attempts at the Exercises given in Lesson 5, pages 550–551, with the keys in this page and in page 555 and re-studied any of the rules which errors may show have not been sufficiently grasped, and then checked once again, the student may now proceed to the consideration of what is known as the Doubling Principle.

Doubling Principle. Curved strokes may be doubled in length to indicate the addition of the syllable *tr*, *dr*, *THr*, and in common words—*ture* ; thus, knee, neater, enter; fie, fighter, father, fodder, feature; nigh, nitre, neither; nature, natural, central; folder. Note that stroke *l*, standing alone, is doubled for *tr* only; thus, letter, letters, alter; but leader, leaders, leather.

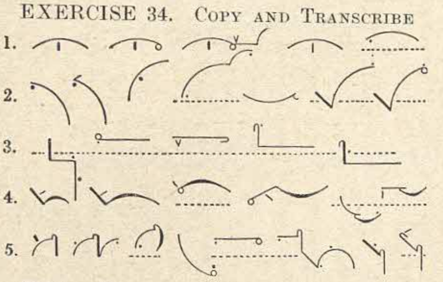
A straight stroke may be doub'ed in length if it follows another consonant, or circle *s*, or has a final hook or joined diphthong; thus, cater, but skater, educator; potter, but captor, spider; water, but wonder, operator; daughter, but tutor, doubter, imitator.

mp, mb may be doubled for the addition of *-er*, and *ng* for *-kr, -gr*; thus, jump, jumper, tamper; long, longer, Ingersoll.

The hooked form is used for *mpr, mbr*, when immediately following an upstroke or *k*: in all other cases the double-length form is used; thus, lumber, hamper, cumbersome, but damper.

The double-length form is used for *ng-kr, ng-gr* initially and when following a circle or an upstroke; in all other cases the hooked form is written; thus, anger, anchor, anchorage, sinker, rancour, linger, but bunker, drinker, canker.

EXERCISE 34. COPY AND TRANSCRIBE



When the present tense of a verb is written with either a double-length character or a hooked form, the past tense is written with the halving principle; thus, ponder, pondered; counter, countered; hinder, hindered; matter, mattered; linger, lingered; slumber, slumbered.

The light sound of *thr* is represented by the hooked form; thus, Arthur, panther.

The doubling principle is not employed when a vowel follows final *tr*, *dr*, etc.; thus, flatter, but flattery; anger, but angry; winter, but wintry.

All double-length downstrokes are written through the line. Double-length horizontals are written above the line for the first position, and on the line for the second and third positions. Double-length upstrokes are written in accordance with the usual rules of position writing—above, on, or through the line.

The doubling principle can be usefully employed in phraseography for the indication of the words *their*, *there*, *other*, and *dear*, as follows:—

in their opinion, in other cases, I know there is, for some other reason, upon their, my dear madam, I think there is, my dear sir.

Note the phrases: had not, do not; did not.

ABBREVIATIONS

cannot; gentleman, gentlemen; particular, opportunity; child; build-ing; told; tried, trade, toward, towards; hand, under; chaired, cheered; sent; third, short; spirit; yard, word; rather, writer; wonderful-ly; therefore; school, schooled.

EXERCISE 35
WRITE IN SHORTHAND

1. I-*think-there-is a great*-deal *of-truth in-the* statement made, *and-we should, therefore,* look *very-care*fully into-*the* matter, *and* see

whether it-is possible *to* remedy-*the* present state-*of* affairs.

2. I-know-*there-is a* list *of* figures *on hand, but* I-*do-not-think that-we-can* rely upon-*their* accuracy.
3. *The* crowd *in-the school yard cheered with spirit, and* gave-*the writer a wonderful* reception.

Prefixes. We will now discuss the manner in which several frequently-occurring prefixes may be rapidly and legibly expressed in Pitman's Shorthand.

Initial *con-*, *com-*, is represented by a light dot; thus, compel, compelled, commend, commence, control, controlled, connect, connexion.

In words like *commend*, *commence*, the stroke *m* is not written, because the *m* is contained in the prefix *com* and it need not be repeated. So also the stroke *n* is not written in such words as *connect*, *connexion*.

Note commission, commissioner, where the use of the fuller form gives a more facile outline.

When *con-*, *com-*, *cog-*, occur in the middle of a word they may be represented by disjoining the form immediately following the *con-*, etc.; thus, I am compelled, in compliance; becoming, incompetent, recognize, circumference.

Accom- is represented by *k*, joined or disjoined; thus, accommodation, accomplish.

Intro- is expressed by the double-length ntr; thus, introduce, introducing.

Magna-, etc., is expressed by disjoined *m*, as in magnify, magnitude, magnanimous.

Trans- may be contracted by omitting the *n*; thus, transfer, transmit, transgression; but sometimes the full outline is preferable, as in transit, transaction.

Self- may be represented by a disjoined circle *s*, written in the second vowel-place; thus, self-reliance.

Self-con- is expressed by a disjoined circle *s*, written in the place of the *con-* dot; thus, self-control.

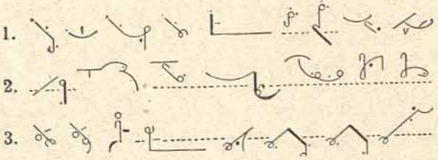
In- before *str*, *skr*, *h* is expressed by a small hook written in the same direction as the circle; thus, instrument, inscriber, inhabit. This small hook is, however, never used in negative words. Note hospitable, inhospitable.

The prefixes *il-*, *im-*, *in-*, *ir-*, *un-*, are represented generally by repeating the *l*, *m*, *n*, or *r*, as in legal, illegal, mortal, immortal; necessary, unnecessary; redeemable, irredeemable.

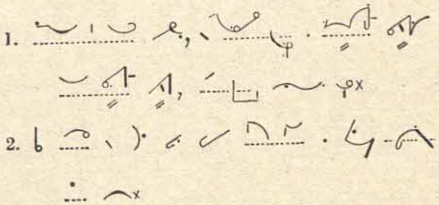
The prefixes *il-* and *ir-* may, however, be represented by writing the initial *r* or *l* downwards, where the rules permit of this being done; thus, resolute, irresolute, limitable, illimitable.

EXERCISE 36

COPY AND TRANSCRIBE



KEY TO EXERCISE 31



KEY TO EXERCISE 32

1. There is no justification for the action of Mr. Hawkins. whose charges are founded on mere generalization.

2. The importance of the occasion is not lost sight of by the shopkeepers in the neighbourhood.

KEY TO EXERCISE 33

1. According to the evidence of the guard of the train, the packets were intact when handed over at the end of the trip.

2. As indicated in the report, there is great need for vigilance on the part of the staff in the Accounts Department.

3. It has been stated that the cost of the machine, over a thousand pounds, was hardly justified by the results.

LESSON 7

Suffixes and Diphones

Suffixes and Word-Endings. The stroke *ng* is usually employed for the termination *-ing*; but in cases where the stroke would be awkward to write the sound *-ing* may be represented by a light dot, thus, requesting, meeting, covering, serving, coughing, winning, getting, assuring, teaching, breeding, muttering. Usually, the dot *-ing* is used after a light downstroke.

Where *-ing* is represented by a dot the plural *-ings* is represented by a light dash, thus, meeting, meetings; morning, mornings.

The suffix *-mental-ly-ity* is expressed by a disjoined *mnt*, thus, experimental, sentimental-ly-ity.

The endings *-fulness*, *-lessness*, are expressed by a disjoined *fs* and *ls* respectively, thus, thoughtfulness, thoughtlessness.

The suffix *-ship* is represented by *sh*. joined or disjoined, as convenient, thus, friendship, citizenship, hardship.

The endings *-ality*, *-ility*, *-arity*, *-ority*, are expressed by disjoining the stroke which comes before the ending, thus, for(m)-ality, lia(b)ility, regu(l)arity, ma(j)ority, mi(n)ority.

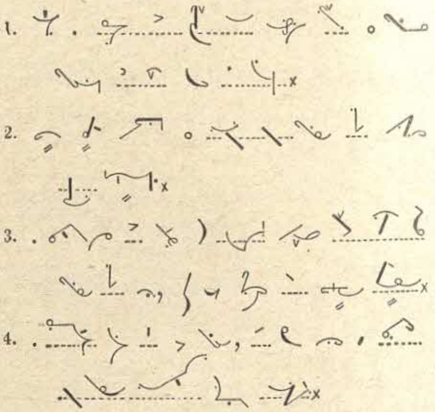
The endings *-logical-ly* are expressed by a disjoined *j*, thus, psychological-ly.

The suffix *-ly* is expressed by a joined or disjoined *l*, and in some cases by the hooked form, thus, fairly, instantly, deeply, actively, sensitively.

The endings *-ward*, *-wart*; *-yard* are expressed by a half-sized *w* and *y* respectively, thus, backward, forward, stalwart; backyard, brickyard.

EXERCISE 37

COPY AND TRANSCRIBE



EXERCISE 38

WRITE IN SHORTHAND

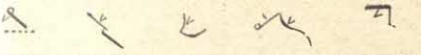
1. paying, hiring, pouncing, folding, promoting, searching.
2. casting, castings, brutality, suitability, legibility, possibility.

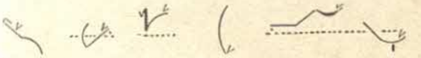
3. consignment, resentment, horsemanship, lawfulness, lawlessness.

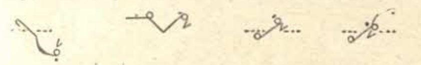
Diphones. In some words we have two consecutive vowels, pronounced separately. For example, in the word *idea* it will be noted that the ē and the ă are both clearly sounded. Such vowels are represented by the angular signs and , which are termed *Diphones*.

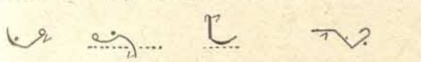
The first sign represents a dot vowel immediately followed by another vowel—long or short, and the second represents a dash vowel similarly followed by another vowel. The signs are written in the place of the *first* vowel of the combination. Study the following words.

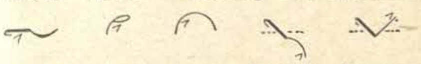
EXERCISE 39

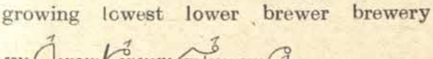

sahib payable saying surveyor gaiety


player theory ideal theatre carrying piano


previous experience serious seriously

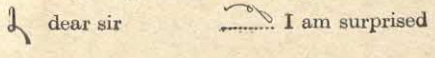

various senior drawing co-operation

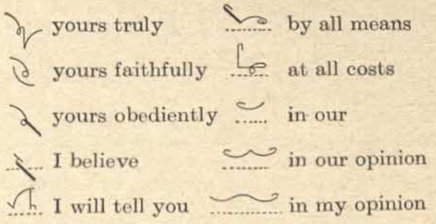

growing lowest lower brewer brewery


cruelty jewels ruinous Lewis

The consecutive vowels in some words like *question*, although not sounded separately, are, for convenience, represented by the sign , thus, question, union, suggestion, million.

The art of phrasing, which plays an important part in speed writing, will be dealt with fully in a future Lesson, but in the meantime the reader should make himself thoroughly conversant with the following frequently occurring phrases.

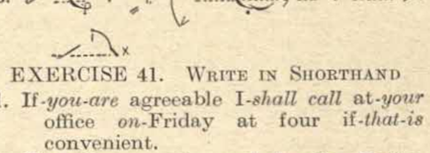

dear sir I am surprised


yours truly by all means
yours faithfully at all costs
yours obediently in our
I believe in our opinion
I will tell you in my opinion

ABBREVIATIONS

anything, nothing, something, everything, selfish-ness, inscribe-d, inscription, instruction, instructive.

EXERCISE 40. COPY AND TRANSCRIBE



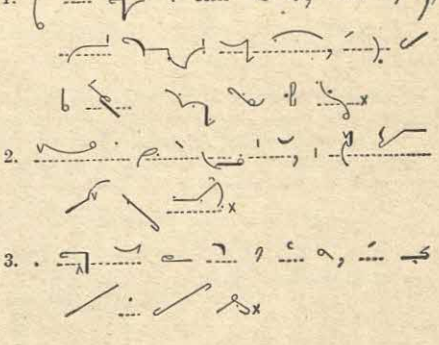
EXERCISE 41. WRITE IN SHORTHAND

1. If-*you-are* agreeable I-*shall call* at-*your* office *on*-Friday at four if-*that-is* convenient.
2. *The* theory advanced by-*the* Italian historian *is very* ingenious. *On-the instructions of-the* commissioner *the inscription on-the* wall *was* removed *as it was* considered unsuitable.

Keys to Exercises 37–38, 40–41 in page 559.

KEY TO EXERCISE 35

Dictate repeatedly until it can be written at least at 60 words per minute easily and accurately. Key to Exercise 34 in page 556.



KEY TO EXERCISE 34

1. motor, motors, motor-cycle, mutter (mother), matter.
2. ardour, harder, later, latterly, neuter, builder, builders.
3. dictator, scatter, kinder, tractor, director.
4. bump, bumper, sombre, hunger, finger, conquer.
5. older, elderly, lather, features, canters, caterpillar, better, plotter.

KEY TO EXERCISE 36

1. competent, common, compensate, compensation, conductor, constant, constable, incomplete, recognized.
2. reconsider, commissioner, accomplice, introducing, magnificence, translated, transmission.
3. self-possession, self-possessed, self-controlled, instructor, inhale, inhabitants, inhabited, inherent.

LESSON 8

Advanced Phrasing and Dictation

Abbreviated W. It will be remembered that an initial semicircle attached to represents *w*, as in walk, wag, womanly, war, worry. In a small group of words *medial w* may also be represented by a small semicircle, the left half of a circle representing *w* followed by a dot vowel, and the right half of a circle representing *w* followed by a dash vowel. The study of the following examples will make this clear: memoir, reservoir, twelve, twenty, frequent, subsequent, herewith, sandwich, Brunswick, Cornwall, breakwater, misquoted, guess-work, gasworks, driftwood. It will be seen that the semicircle is written in the position of the vowel following the *w*. Note the following special forms:—quality, qualify, qualification, somewhat.

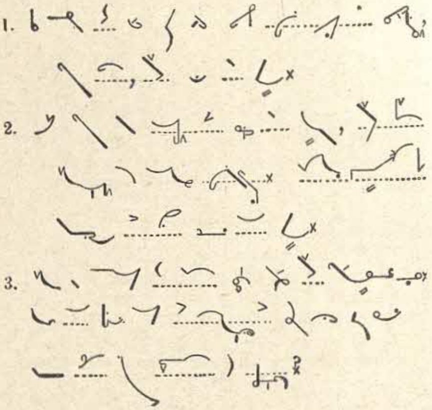
Negative Words. It is very important that positive and negative words should be clearly distinguished. In some cases this is easily done simply by applying the ordinary rules for the writing of *r* or *l*. Thus we have resolute but irresolute, relevant, but irrelevant. In cases where the distinction cannot be made in this way the initial consonant is repeated, **thus,** legal, illegal; necessary, unnecessary; moderate, immoderate; noticed, unnoticed; known, unknown; material, immaterial.

ABBREVIATIONS

probable-ly-ility, expect-ed, suspect-ed, inspect-ed-ion, together, altogether, yesterday, investigation, January, February, knowledge, acknowledge.

EXERCISE 42

COPY AND TRANSCRIBE

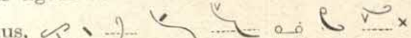


EXERCISE 43

WRITE IN SHORTHAND

1. *Whether-the* action *of-the* committee *was* legal or illegal *is expected to-be* fully discussed at-*the investigation in January*.
2. *It-is*-unnecessary *for* us *to* state *that-the* material, *which-was* made by Cornwallis *and* Hardwick, *is of-the* best quality.

Figures. The figures *one* to *seven* and the figure *nine* are written in shorthand: thus,



All other numbers, except round numbers, are usually represented by the ordinary Arabic numerals. *Hundred* is represented by , *thousand* by (or and *million* by , and thus we have 4 for 400, 4(for 4,000, 4 for 400,000; 5 for £500, 5 for £500,000.

Advanced Phrasing. The reader is already acquainted with the general principles of phrasing, by which the outlines for certain groups of words may be joined, thus saving time and increasing the speed of writing. In more advanced writing this principle is considerably extended, and in this Lesson we will consider its further development. We will first of all deal with the manner in which Circles, Loops, and Hooks play a part in phrasing.

1. The small circle, besides being used for *as, has, is, his* in the ordinary way, may be used to represent *us*, as in of us, to us, from us, let us. (Note please let us know).

2. The initial large circle may be used to represent—

(*a*) *as we*, as in as we have, as we have said, as we think.

(*b*) *as* and *w*, as in as well as, as well as our, as well as your, as will be seen.

(*c*) *as* and *s*, as in as soon as, as soon as they were, as soon as we have. (Note also as soon as convenient, as soon as possible.)

3. The medial and final large circle may be used to represent the following—

(*a*) *is* and *s*, as in it is said, it is suggested, it is certain.

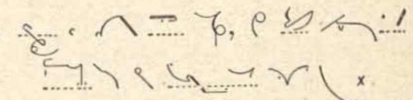
(*b*) *his* and *s*, as in for his sake, at his side.

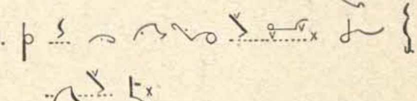
(*c*) *s* and *s*, as in in this city.

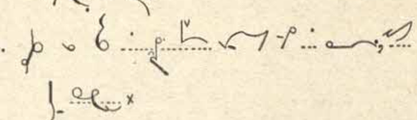
(*d*) *s* and *has*, as in this has been.

The foregoing lists are, of course, not exhaustive, and other phrases may be constructed on the lines suggested. Phrases should be practised until they can be written easily and rapidly.

EXERCISE 44. COPY AND TRANSCRIBE

1. 

2. 

3. 

Keys to Exercises 42–44 are given in page 559.

Loops and Hooks. Now to consider how the loops and hooks may also be used to advantage in phrasing.

The loop *st*, for instance, is used for *first*, as in at first, for the first time, in the first place. The *nst* loop is used for *next*, as in Monday next, Wednesday next.

The *r* and *l* hooks are employed to represent a few miscellaneous words, as, for example, in in our, in our opinion, it appears, it appears that, at all, by all, by all means, it is only necessary, it can only be, it may only be.

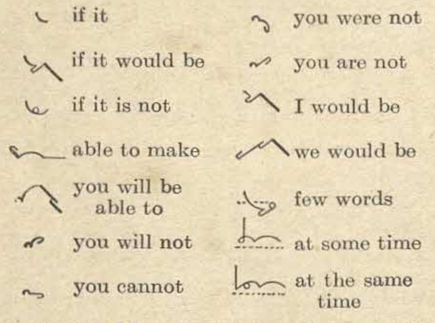
The *n* hook may be used for *than, own, been*, as in (*a*) better than, older than, more than, rather than, smaller than.

(*b*) your own, our own, their own.

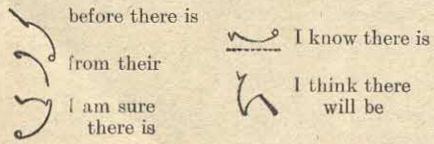
(*c*) I have been, we have been, I had been, we had been, they had been.

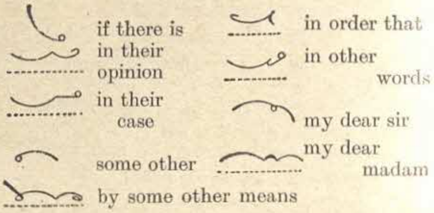
The *v* hook may similarly be used for a number of miscellaneous words. Note how it is employed in the following phrases— ought to have been, who have, who have been, which have, which have been (note, however, we have, can have); out of, rate of, state of affairs, state of things, get rid of; Monday afternoon, Monday evening; at all events, into effect.

The Halving Principle. This can be adapted to indicate several words. Remembering the rule that by halving a stroke one adds *t* or *d*, there will be little or no difficulty in comprehending the following phrases.

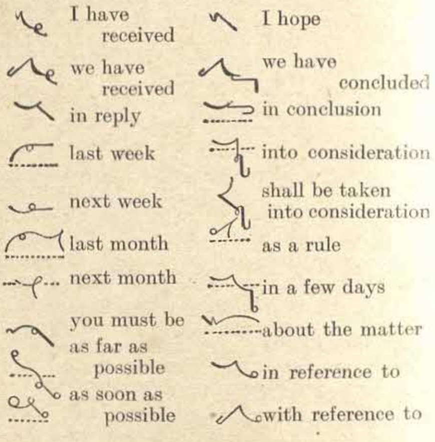


The Doubling Principle. This can also be used in phrasing, thus :





Other Phrases. These can be formed by the omission of certain consonants, syllables, or words. The examples which follow should be carefully studied and practised.



In the space at our disposal it has been possible to touch only very lightly on advanced phrasing, but the foregoing examples will show how the judicious use of phrasing must, as a matter of course, increase speed in writing. The student should seek to extend his knowledge of this aspect of the system, but he should remember that phrasing, like most other things, can be overdone. It should be borne in mind that unless a phrase is speedy, easily written, and easily read, it had better be avoided. A "classic" example of a phrase which does not fulfil all these conditions is × It is certainly speedy and easily written, but would it convey to you the assertion *I can cook cake?* We do not think so; it is, in fact, a bad phrase.

It is suggested that a good method of practising these phrases is to take them in groups of five or six, copying them carefully on the top line of the notebook. On the next line write them again, slightly faster if possible, and so on until each of them can be written smoothly and rapidly. A light touch in writing should be cultivated. The *Phrase Drill Notebook* is very convenient for practice of this nature.

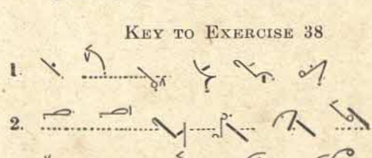
Dictation. At this stage of the study the reader who has carefully followed this Course of Lessons is capable of undertaking general, as apart from graded, dictation. There are many suitable dictation books available, and it should not be a difficult matter to enlist the services of a friend as dictator. The speed of dictation should be such that the shorthand characters can be formed clearly and unmistakably. Very few vowels need be inserted when taking down from dictation. It is essential that as much dictation practice as possible should be obtained—half an hour a day at least if practicable. Phrase drill and facility exercises will help to cultivate fluency of hand movement, which is an important essential in speed work. The student is again reminded that the pen should be held lightly, as a tight grip is tiring and detrimental to speedy movement across the paper.

Following are given the final sets of Keys—those required for Lesson 7 (pages 554–555) and for the last Lesson (pages 556–559).

KEY TO EXERCISE 37

1. Only the skill of the driver in instantly applying his brakes prevented what might have been a fatality.
2. Mr. Jones regretted his inability to be present at the regimental dinner on Monday.
3. The hopelessness of the position was fully recognized by the majority of those present at the meeting, which was under the chairmanship of Colonel Johnson.
4. The scaffolding fell on to the pavement, and several men who happened to be passing narrowly escaped injury.

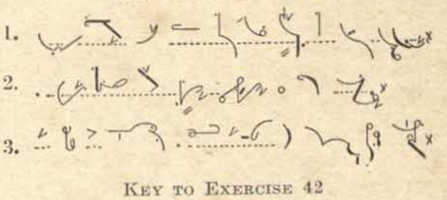
KEY TO EXERCISE 38



KEY TO EXERCISE 40

1. The man answered the various questions of Mr. Lewis without any hesitation.
2. You should by all means visit the British Museum when you are in London next month.
3. We visited the Gaiety Theatre last evening, and spent an agreeable hour or two.

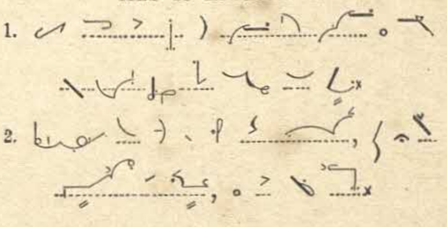
KEY TO EXERCISE 41



KEY TO EXERCISE 42

1. It is expected that the fund which was opened yesterday will reach a hundred pounds, probably more, by the end of January.
2. I shall probably be in town on the second of February, by which time I have no doubt your investigation will be completed. I leave Cornwall at the beginning of the last week in January.
3. I have to acknowledge that I am somewhat puzzled by the Brunswick case. Have you any definite knowledge of the movements of the suspected men who were seen together shortly after the crime was discovered?

KEY TO EXERCISE 43



KEY TO EXERCISE 44

1. Please let us know when you will be again in this city, as we think that we shall require a large quantity of your special fabric in the early future.
2. It is said that the men left the premises by the skylight. It is certain that they did not leave by the door.
3. It is suggested to us that this is a suitable time to launch such a scheme, and we shall do so as soon as convenient.